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Mr. Marvin Nichols, Chief,
MSHA Office of Standards, Regulations, and Variances
1100 Wilson Blvd., Room 2313
Arlington, Virginia 22209-3939

Re: MARG Diesel Coalition Comments on MSHA's Diesel Particulate Matter (DPM) Proposed Rule For Underground Metal/Nonmetal Mines 68 Fed. Reg.48668 (August 14, 2003)

Dear Marvin:

The MARG Diesel Coalition[1] appreciates this opportunity to comment on the above referenced MSHA proposed rule setting diesel particulate limits for underground metal and non- metal mines.

In a cooperative effort, DOL, MARG and the NMA agreed to an interim, partial settlement of our court challenge to the January 2001 rule. That agreement creates a "settlement standard" and this rulemaking is intended to implement that agreement. To the extent the proposed rule follows the provisions of the settlement agreement, we endorse its provisions. However, we believe that the proposal does not fully implement the agreement nor take the actions needed to comply with MSHA's legal duties. We incorporate our prior comments into this rulemaking record and we submit the attached exhibits as well as these comments for consideration by MSHA as it determines the content of the final rule.

Delete The 160 Standard In This Rulemaking

Initially, the conclusion of Dr, Jonathan Borak, a Yale University physician, toxicologist and faculty member, internationally recognized as an expert in risk assessment and toxic substances, is critical to

[1] The members of the Coalition are Cargil Salt, Carmuese Lime, FMC Wyoming, General Chemical, IMC, Morton Salt, Newmont Mining, Stillwater Mining, and the National Mining Association, with recent contributions and assistance from the National Stone, Sand & Gravel Association, and past support from a number of other companies and associations. The Coalition was formed 15 years ago and has sponsored peer-reviewed and published literature on diesel exhaust matters and placed extensive information into the record of this rulemaking, including the industrial hygiene study by Drs. H. Cohen, J. Borak, and T. Hall demonstrating that MSHA's original proposal to measure total carbon was not feasible due to interferences from non diesel sources. The Coalition participates in the ongoing study of miners by NIOSH and NCI to determine if diesel exhaust causes adverse health effects, and if so at what level of exposure.

the disposition of this rule: "My updated review of the scientific literature confirms my prior opinion: the MSHA PELs are not scientifically supported." See Exhibit 1 (Dr. Borak's comments and attached appendices were submitted under separate cover). Dr. Borak's views have not changed since he submitted his prior comments to MSHA, and as he points out in his updated report (attached as Exhibit 1), the scientific literature and the scientific community continue to support his views and place MSHA's position in isolation.

In fact, MSHA's proposal is unique among regulatory agencies and in stark contrast to the standards of OSHA, FAA, Coast Guard, FRA, and other federal and state agencies with similar health and safety responsibilities. Moreover, MSHA's proposal is contradicted by EPA's conclusion that the science does not support the establishment of specific DPM limits and with the deletion of the DPM threshold limit value (TLV) by the American Conference of Governmental Industrial Hygienists (ACGIH), the agency that provided the basis for every other MSHA health standard.

We are disappointed that MSHA has not yet deleted the 160-microgram limit, scheduled to take effect in 2006. We strongly encourage MSHA to delete the 160 limit immediately, in this rulemaking, and many of our comments are directed at the need for MSHA to act now.

The Interim Partial Settlement with MSHA (attached as Exhibit 2) recognizes the industry's position that the MSHA DPM limits are not scientifically justified or technically or economically feasible, but permits implementation of the 400 microgram total carbon limit, converted to elemental carbon, as a practical compromise of the legal dispute, in exchange for a reexamination of the 160 limit and critical changes to the flawed 400 rule. While we appreciate MSHA's settlement efforts and attempts to "fix" the flawed rule, we insist upon the deletion of the 160 limit now, in this rulemaking.

The MSHA Federal Register notice seeks comments on the 2006 160 TC limit now, but notes that the Agency contemplates issuing another Notice of Proposed Rulemaking to address this issue separately. All parties to this rulemaking are fully aware that the MARG Coalition has rejected this additional and delaying procedure as inconsistent with the Interim Partial Settlement Agreement, which envisioned one rulemaking, not two. Moreover, all parties to this rulemaking and the litigation are aware of the MARG Coalition's position that the 160 TC limit is invalid, was issued contrary to the provisions of law, and thus is void and must be deleted now in this rulemaking.

It is well within the Secretary's authority and discretion to delete the 2006 160 limit now, in this rulemaking, since all parties have notice that the validity of the limit is an issue, and MSHA has sought comments regarding the limit. The Secretary has the discretion to act now to ensure compliance with statutory duties, avoid the uncertainty that would be produced by a separate, delaying rulemaking, and respond to information learned in this proceeding. Moreover, the 2006 limit offers no protection since it is not based on any risk assessment or health analysis, is not feasible and is not effective now. For all of these reasons and others, the 2006 limit is not a "standard" for purposes of the Act's so called "prohibition on reducing protection," and if it is a standard, its elimination does not reduce protection because it provides no demonstrated protection,

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quantifiable or otherwise, as demonstrated by the comments below and in the exhibits to these comments.

DPM Rules Were Rushed To Publication Without An Adequate Scientific Basis

Since the rule was rushed to publication, on the last day of the last Presidential Administration, scientific evidence and extensive field testing has proven what we knew at the time: the rule was an unfortunate "shoot first, aim later" approach to regulation. This rulemaking is the "tip of the iceberg" of the massive efforts and resources dedicated in the last three years to re-examine the rule, and try to "fix" its critical flaws. Yet, these efforts should have been taken well before the rule was ever promulgated and must be accelerated now, as we approach enforcement of the settlement agreement terms, and the prospect of an unachievable, unjustified 2006 standard. We encourage MSHA and DOL to end this struggle with the errors of the past, which is causing all of us to miss opportunities to focus our limited resources on the needs of today and the future.

The Mine Act and Data Quality Mandates Require that The 160 Standard Be Deleted Now

Mine Act Section 101(a)(6)(A) provides:

> The Secretary, in promulgating mandatory standards dealing with toxic materials or harmful physical agents under this subsection, shall set standards which most adequately assure on the basis of the best available evidence that no miner will suffer material impairment of health or functional capacity even if such miner has regular exposure to the hazards dealt with by such standard for the period of his working life. Development of mandatory standards under this subsection shall be based upon research, demonstrations, experiments, and such other information as may be appropriate. In addition to the attainment of the highest degree of health and safety protection for the miner, other considerations shall be the latest available scientific data in the field, the feasibility of the standards, and experience gained under this and other health and safety laws. Whenever practicable, the mandatory health or safety standard promulgated shall be expressed in terms of objective criteria and of the performance desired.

30 U.S.C. § 811. (emphasis added).

OMB/DOL Information Quality Guidelines:

On December 21, 2000, Congress passed Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (the "Act"). In accordance with the Act, the Office of

Management and Budget ("OMB") published final government-wide information quality guidelines entitled "Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility and Integrity of Information Disseminated by Federal Agencies" ("OMB Guidelines"). 67 Fed. Reg. 369 (January 3, 2002). The OMB Guidelines incorporate the congressional standards required for health decisions under the Safe Drinking Water Act of 1996 (42 U.S.C. 300g-1(b)(3)(A) & (B)). 67 Fed. Reg. at 377. On October 1, 2002, the Department of Labor ("DOL") issued information quality guidelines ("DOL Guidelines"). MSHA has adopted the position to follow both the DOL guidelines and the OMB guidelines.

MSHA's DPM rule does not comply with the Congressional, OMB and DOL information quality guidelines because (i) the DPM rule is not supported by an adequate scientific basis, and (ii) it fails to meet the "reproducibility" standard required for disseminating influential information. See Letter to OMB, attached as Exhibit 3, and the comments of Dr. Borak (heath risk assessment and accuracy of sampling and analysis system) and H. John Head (feasibility analysis), See Exhibits 1, 4 and 5.

Among the violations of its legal obligations, MSHA failed to:

- base its rule on sound research, demonstrations and developments. 30 U.S.C. § 811.
- use "the best available, peer-reviewed science and supporting studies conducted in accordance with sound and objective scientific practices." 42 U.S.C. 300g-1(b)(3)(A); and the latest available scientific data. 30 U.S.C. § 811.
- "ensure that the presentation of information about risk effects is comprehensive, informative, and understandable." 42 U.S.C. 300g-1(b)(3)(B).
- [in disseminating influential information] "include a high degree of transparency about data and methods to facilitate the reproducibility of such information by qualified third parties." 67 Fed. Reg. at 377.
- ensure that bias and conflicts of interest, as demonstrated in the deposition testimony of Thomas Tombs (formerly employed by MSHA) do not taint the dissemination of influential information in the proposed DPM rule. (See Exhibit 6; discussed in greater detail herein).
- adhere to the experience gained under other health and safety laws. 30 U.S.C. § 811.
- promulgate rules that are technically and economically feasible. 30 U.S.C. § 811.

Since MSHA violated its statutory duties and the prior administration exceeded its authority in promulgating the 2006 160 limit on the last day of its term, this Secretary has the duty and authority to delete the 160 limit now to comply with the law.

<u>MSHA Issued DPM Rules While Its Research Agency, NIOSH, Seeks Reliable Evidence</u>

The National Institute of Occupational Safety and Health is MSHA's Congressionally designated science advisor under the Mine Act. The ongoing multimillion dollar NIOSH / NCI study of possible diesel related health effects in miners was commissioned because of suspected health concerns that were not supported by existing science. Because there was a lack of evidence to support diesel exhaust health risk assessments, NIOSH and NCI are in the tenth year of a massive on-going study. NMA and the MARG Diesel Coalition supported the study, and Coalition member mining operations have participated and spent vast resources in these efforts. Repeated Congressional appropriations instructions mandated the highest level of scientific review for the study and the need for MSHA regulatory efforts to be "informed" by this study. Yet, the MSHA rule did not wait to be informed by the study and the 160 standard should be deleted now as premature and contrary to MSHA's statutory mandates.

MSHA's DPM Rule Is Contradicted By Other Agency Reliance On Exhaust Gas Limits

All other federal agencies (e.g. governing diesel engines in construction, tunneling, rail, truck, marine or bus depots, repair facilities, agriculture and aviation), led by OSHA, rely on regulating the gaseous portions of diesel exhaust (e.g. CO, NO, NO_2) for their protective standards for the workplace. Their silence on diesel particulates demonstrates MSHA unique, isolated and erroneous approach to diesel regulation. Even though OSHA regulates far more work place diesel engines and potentially exposed personnel than MSHA (including tunneling with potentially higher exposures than mines), MSHA stands alone in its experimental regulation of diesel particulate matter through its carbon components. By ignoring the actions of other agencies with the same mandates as MSHA, MSHA has violated its statutory mandate under Section 101(a)(6)(A) of the Mine Act.

MSHA Now Admits That The Very Basis Of The 160 DPM Rule Is Wrong And That Admission And The Scientific Evidence Mandate That it Be Deleted

The MSHA decisions to measure and limit diesel exhaust through one of its thousands of components, "total carbon" particulate, was based on the use of an experimental sampling device and a new analysis method. All of the MSHA feasibility opinions and analysis used to support the rule were based on the total carbon regulatory scheme that had never been: (1) used by MSHA or any other regulatory agency; (2) tested by sampling, analysis and measurements in industrial settings; (3) directly associated with any specific disease risks; or (4) correlated to the thousands of other components of diesel exhaust to determine if carbon measurements accurately and consistently represent diesel exhaust levels.

NMA and the MARG Coalition funded research performed by Drs. Howard Cohen, Thomas Hall and Jonathan Borak, which demonstrated that total carbon could not be measured, as required by MSHA's proposed rules, without interference from mine ores that contain carbon and other sources of non diesel carbon, such as oil mist and tobacco smoke. The research results were placed into the rulemaking record and published, and NIOSH placed similar conclusions into the rulemaking record. While MSHA's Jan 19, 2001 final rule ignored this overwhelming evidence, our litigation challenging the rule resulted in MSHA's admissions and the current proposed change to an elemental carbon standard, which we appreciate. As a settlement standard, EC is far superior to TC

since it suffers from fewer interferences. But at the 160 TC level or at the EC conversion of 160 as proposed, compliance cannot be measured accurately and the standard is not feasible.
Attached as Exhibit 4 is an analysis of the error and variability of the MSHA sampling and analysis system incorporated in the proposed final standard based on three independent sets of data: (1) MSHA's 31-Mine Site Study Samples; (2) MSHA's Compliance Assistance Mine Visit Samples; (3) the MARG/NISOH Study Samples. The analysis proves that the system is not accurate and not feasible. We emphasize the following comments of Dr. Borak:

> Based on the data analyzed above, we conclude that that the Error Factor (EF) presented in the proposed Final Rule is too small. In the MARG study, 32% of baskets containing at least one sample in the 75-200 $\mu g/m^3$ range had a CV $\geq$12.5 %. That finding is inconsistent with the NIOSH criteria for appropriateness of analytical methods and does not meet guidelines presented in the proposed Final Rule.
>
> With respect to MSHA, its EF is calculated on the assumption that CV_A, of which one component is punch-repunch differences, will be less than 4.6% for samples in which EC $\geq$308 $\mu g/m^3$ and less than 7.2% for samples in which EC $\geq$123 $\mu g/m^3$. But data from the two MSHA databases indicate that punch-repunch differences often exceed the total value of CV_A, thus indicating that the formula for EF underestimates the actual imprecision of the MSA method. Moreover, the punch-repunch differences were greater than the total EF in 4.5% of the samples with punch-repunch data in the Compliance Assistance database and 9.5% of such samples in the 31-Mine database. Accordingly, it is almost certain that both of those databases document failure to meet the NIOSH and MSHA acceptability criteria.
>
> It is unfortunate that MSHA has not evaluated its proposed method by means of systematic determinations of the CV for samples obtained under real mining settings. Lacking such data, it does not seem possible to conclude whether the proposed sampling methods and their related PELs meet the NIOSH and MSHA appropriateness criteria discussed above. As a result, there is an apparent failure to demonstrate feasibility of the proposed method despite the Agency's two databases, which raise significant concerns about the methods proposed in the Final Rule.

See Exhibit 4.

The device that MSHA helped develop for measuring diesel carbon particulate for this rule, the "submicron impactor," was shown to be flawed before the rule was finalized and again during field tests following the litigation interim settlement agreement. MSHA and the manufacturer have attempted repeated repairs and redesigns, and MSHA has concluded (again erroneously) that the problems are solved and that its proposed rule is appropriate. However, an experimental sampling system that continues to undergo development cannot be used for enforcement actions that impose sanctions and mandates for engineering controls.

The "NIOSH Analytical Method 5040" (the "5040 Method"), which MSHA originally adopted for analysis of diesel total carbon, had never been commercially used when it was adopted and was originally approved by NIOSH for its own use, based on tests involving less than 20 samples. MSHA's rule adopted the 5040 Method while ignoring comments about its inapplicability and potential interferences. Since then, commercial labs have been struggling to buy new equipment, and understand its applicability, variability, accuracy, and precision, and mine operators have been forced to spend countless resources in an effort to respond to and correct MSHA's invalid decision.

While we appreciate MSHA's latest efforts to correct the system, and its acknowledged preamble experiments to achieve acceptable results, the ongoing and repeated "fix on the run" approach will continue to produce results which are not meaningful, and instead will produce erroneous enforcement actions and further waste resources. The accuracy and precision of the 5040 Method, as currently used by MSHA (the "MSHA Method") is not feasible for use as an enforcement tool at the 160 Total Carbon Level and the level should be deleted in this rulemaking.

MSHA Should Never Prohibit Options For Protecting Miners

Unlike every other MSHA health standard, MSHA prohibited employee protection with personal protective equipment in its January 19, 2001 DPM rule. We are thankful that MSHA now recognizes this grave error, and we endorse the proposal to permit PPE. The need to correct this error should serve to remind the agency, and any reviewing authorities or courts, of the fatal flaws incorporated in the rushed and premature rule. Moreover, we strongly urge MSHA to delete the rule's prohibition of rotation of personnel as a protective option. It makes no sense for a safety and health agency to prohibit effective options for employee protection.

MSHA's 160 Standard Is Tainted By Conflicts of Interest

MSHA'S 160 microgram (.16 milligram) Total Carbon DPM limit is based on a now revoked ACGIH TLV, drafted by an MSHA senior staff member (Thomas Tombs), who served on the ACGIH TLV committee, while he was drafting the MSHA rule. See Exhibit 6, the May 23, 2003 Deposition Transcript and transcript extracts of Tom Tombs. Following disclosures in the trona ACGIH litigation, DOL signed a settlement agreement requiring it to investigate conflicts identified in the litigation. DOL has issued a new policy, which now prohibits the overlapping activities that resulted in the MSHA and ACGIH standards, but MSHA has not yet withdrawn the 160 DPM standard. While the staff member has now retired from MSHA, and no longer serves on the ACGIH TLV committee, the damage must be corrected and the tainted standard withdrawn, just as ACGIH has withdrawn their tainted and unsupported standard.

The DPM Rule Has Not Been Demonstrated to Be Feasible

As demonstrated by the comments in Exhibit 5 by internationally recognized, mining engineering expert, H. John Head, MSHA has not demonstrated that the 400 or 160 limits are feasible. The industry's tests of MSHA's anticipated primary dpm control, retrofit exhaust filters have had only limited success in meeting the 400 limit and no success in meeting the 160-microgram limit. MSHA's preamble notes that 30% of the mines tested in the agency's baseline sampling program were not in compliance with the 400 standard. While the preamble describes many of the MSHA recommendations to those mines, for most it presents no evidence of the recommendations resulting in compliance. Moreover, the MSHA estimate of out of compliance mines is an underestimate, as shown in H. John Head's comments. We emphasize the comments of Mr. Head that the MSHA Estimator used by MSHA to support its feasibility decision is not related to real conditions in the mines impacted by the rule. In addition, we stress that the MSHA presumed primary method of compliance, retrofit filters, have proven unsuccessful in most applications and created greater, far more serious gas release hazards in some situations. These results and the NIOSH partnership tests and research demonstrate the invalidity of MSHA's feasibility conclusion.

Extensions Of Time To Meet the 400 Limit Are Needed Now

We suggest that MSHA avoid additional litigation by establishing a program to issue extensions to mines that justify requests, before counterproductive enforcement visits result in adversarial situations.

Specific Comments on the Proposed Rule And the Preamble

Elemental Carbon: We endorse MSHA's proposal to conform to the interim, partial settlement agreement and measure the 400 DPM limit by measuring its elemental carbon equivalent, rather than total carbon.

<u>EC/TC Conversion Factor</u>: Our independent research led to our prior recommendation of a 320 elemental carbon equivalent to the 400 total carbon limit. MSHA rejected that conversion number and we continue to be concerned that the MSHA conversion will permit unfounded enforcement actions.

<u>PPE</u>: We agree with MSHA's proposal to abide by the settlement agreement and revoke the prohibition on the use of personal protective equipment. We never understood the flawed rule's rationale for prohibiting PPE. We support the proposed respirator provision, which is consistent with all other MSHA regulations.

We also support a provision that would permit the use of air filtering helmets and face shields, as an optional, primary means of compliance with the DPM rule. These helmets do not produce any breathing resistance and are not traditional "respirators." Instead, they create mini atmospheres that protect miners with filtered air. Sampling of DPM for miners using these helmets should take place inside the helmets' clean air environment, just as personal sampling for a miner in an equipment cab takes place inside the cab. MSHA's acknowledgment and acceptance of this technology will encourage manufactures to improve their products and permit flexibility in achieving compliance with the settlement standard.

<u>DPM Sample And Analysis Inaccuracy And "Single Sample" Enforcement</u>: We generally oppose enforcement of occupational health standards based on a single sample because health standards are based on long term exposure and the laboratory results of single samples are not even accurate representations of a single shift exposure.

We continue to be concerned that MSHA's newly developed, and then revised, DPM sampling and analysis "single shift" sample analysis system is not feasible, and does not provide accurate, precise and reliable results. We repeat our request that MSHA retain unused DPM filter sections for analysis by mine operators whenever a violation is alleged. The agency's response that its lab process will not permit the retention of this critical evidence is not true. We are pleased that MSHA's recently issued enforcement policy provide that MSHA will consider operator sampling results, that differ from MSHA results, in determining if enforcement is appropriate. Yet, we remind MSHA that preserving evidence of alleged noncompliance is a duty that MSHA owes to a mine operator that may disagree with an MSHA result.

MSHA's modification to its procedure, mandating analysis and averaging of the results of two punches from each DPM filter (if the first exceeds the limit), and the analysis of blank filters to determine one of the many needed correction factors, is a welcome admission of the inaccuracy of a DPM sampling and analysis system undergoing constant change. But these corrections do not adequately address our concerns.

We are not convinced that the corrections MSHA has added are sufficient to produce an accurate and feasible system and we suggest that Exhibit 4, the Borak, Greg memo provides proof of this major failure and reason to delete the 160 limit.

Rotation of Personnel: We oppose all efforts to restrict or limit options for employee protection. If DPM presents a hazard as MSHA suggests, MSHA's prohibition is contrary to the achievement of the goals of the Mine Act. The prohibition limits flexibility and requires respirators, even if the employer or the workforce prefers not to use them, and wish to institute rotation of personnel to reduce individual exposures. MSHA should delete this prohibition.

No Coal Rules For M/NM: At Federal Register page 48701, MSHA asks if any aspects of Section 75.1914(g) (diagnostic engine emission tests) should be adopted as part of the final rule (bottom of center column). MARG responds that no other provisions are needed, or permitted by the Settlement Agreement. The coal rule is based on engine and filter performance, instead of an exposure limit, and its provisions are not needed for this performance-based rule.

MSHA's Definition of "Significant" DPM Reduction Is Wrong. At Federal Register page 48710, MSHA asks for comments on its belief that a 25% or greater reduction in dpm exposure (from an engineering or administrative control) is "significant" and thereby "effective," for its decision-making on technological and economic feasibility.

First, MSHA states, that the 25% reduction can be achieved by the control itself, or "in combination with other controls," thereby eliminating the critical role of the individual component under consideration, and rendering its guideline meaningless. We suggest that controls must be evaluated independently, but in reference to site-specific conditions and DPM levels, if meaningful decisions are to be made regarding their significance or effectiveness.

We emphasize that the significance of a reduction achieved by a control must be viewed in light of the compliance result, not the percentage reduction. A mine with DPM exposures at 1,000 micrograms can apply a 25% effective control, reducing exposure to 750, however it will not achieve a significant or effective result and will require continuing PPE use, rendering the control not significant.

New Respiratory Protection Provisions Are Not Justified or Needed: At Federal Register page 48712, MSHA seeks comments on whether the DPM rule should include new respiratory protection mandates or plan provisions. The DPM rule should not be extended to address remotely related topics, covered by "stand" alone regulations. We believe that the current respiratory rules (57.5005) are adequate and should be uniformly applied, as they are now, to all respirator applications. As a result, MARG opposes any additional respirator related provisions being added to the DPM rule. In response to MSHA's request for information on costs of these possible additions to the rule (68

Fed. Reg. at 48712), we suggest that MSHA analyze the results of the OSHA lead and cadmium rules and their impact on the regulated industries.

Control Plans Should Be Deleted. At Federal Register page 48716, MSHA seeks comments on its proposal to retain a control plan provision. We oppose the plan proposal, even though it is an improvement over the January 2001 provision. The DPM rule interim settlement permits implementation of a performance-based DPM limit. A control plan merely adds needless paperwork, without benefits, and causes additional costs and the potential for meaningless citations and fines.

MSHA Information Collection Is Burdensome and Does Not Serve Mine Act Goals.
At Federal Register page 48718, MSHA seeks comments on its proposed information collection mandates and (1) whether they are needed for the proper performance of MSHA's functions, including whether the information will have practical utility; (2) the accuracy of MSHA's estimate of the burden of the proposed collection of information; (3) ways to enhance quality, utility and clarity of the information to be collected; and (4) ways to minimize the burden.

First, we note that the DPM sampling and analysis mandates, the plan provisions, the posting requirements, and all of the required records constitute information collection. These information collection activities are: (1) not needed for MSHA to perform its job (as demonstrated by the existence of standards that control other diesel exhaust components); and (2) do not produce information with practical utility since there is no science whatsoever that ties the MSHA carbon limit to any risk of health effects (as demonstrated by OSHA's lack of a similar standard). MSHA could enhance information collection clarity and quality and minimize the burden to operators by relying on its current diesel exhaust gaseous emissions testing and the settlement 400 limit and deleting the contested 160 DPM limit.

MSHA's 31 Mine Study Preamble Discussion Is Wrong. At Federal Register page 48670 to 48671, MSHA sets forth a misleading and incorrect overview of the 31 Mine Study. As parties to the Settlement Agreement, we disavow the implication that we agreed to the described study conclusions or results, or that our disagreements were limited to the few recited by the MSHA preamble. In fact, we are disturbed that our request for acknowledgement and publication of our disagreements with MSHA's interpretations was ignored. For the record, we again will provide our comments on MSHA's report, but we emphasize the following:

- **The Estimator is Wrong:** MSHA's report is based on the MSHA "Estimator" and it is meaningless for a determination of feasibility, as we repeatedly stated in previous discussions and submissions. The Estimator assumes perfect ventilation and air mixing, and applications that are feasible for all equipment and controls. The Estimator does not exist in the real world. MSHA acknowledges it has inadequate information on controls, but does not acknowledge the vast errors resulting from the Estimator's invalid ventilation

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assumptions. We object to MSHA's continued reliance on the Estimator, regardless of its inappropriateness, for its economic and technical feasibility analysis.

- **The Analytical Method Is Not Accurate:** MSHA states, "the analytical method gives an accurate measure of the TC …" That conclusion is rejected by the scientific community and MSHA itself which admits interferences and establishes an attempted method of converting TC measurements to elemental carbon. While MARG prefers EC to TC to reduce interference, we object to the preamble's conclusion. Moreover, we note MSHA's acknowledgement that in this controlled study, about 25% of the samples that were voided (FR page 48683). Most importantly, Dr Borak's memo, Exhibit 4, concludes that the method has not been demonstrated to be accurate or feasible at the 160 level.

- **MSHA's Economic Analysis And Cost Estimates Are Wrong:** MSHA states that the 31-Mine Study supports a finding that the standard is economically feasible. However, MSHA's use of gross revenue as a measure of economic feasibility is invalid. This method ignores the international commodity markets that determine the viability of mines by setting market prices for their production. For the last ten years in the mining industry, volume and gross sales indicated massive losses, more frequently than profitability. MSHA's analysis is flawed since it fails to examine the impact of the additional cost of its regulations on industry margins and viability. The copper, lead, zinc, silver and molybdenum industries are examples of industries driven to financial disaster in the United States by foreign competition and regulatory costs, regardless of gross production or gross sales statistics. The comments of H. John Head, Exhibit 5, provide extensive evidence of MSHA's failure to perform a proper technical and economic analysis, including allocating insufficient costs for compliance and using the wrong basis to determine impact.

<u>MSHA's Feasibility Conclusion Is Rebutted By Its Non Compliance Results</u>: Hardly visible in the many preamble charts and graphs is the single sentence on Federal Register page 48676 indicating that almost 30% of all mines had one or more Compliance Assistance sampling results above 400 TC, adjusted to the EC equivalent. During the compliance assistance visits, many mine operators reported that MSHA was not sampling in the highest DPM concentration locations. MSHA's underestimate of industry DPM levels is confimed by H. John Head's analysis of the data. Moreover, if we are correct in our understanding that this 30% non-compliance rate was based on a highly variable sampling and analysis system (MSHA used the average of two punches, and other corrections), we are convinced that a far larger number/percentage of samples will be above the 400 limit as enforcement sampling begins for employees suspected of having the highest exposures (MSHA's standard sampling protocol), and that none of the mines can achieve compliance with the 160 limit.

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Specific Control Technology Studies: We appreciate MSHA's cooperative efforts in reducing DPM exposures and encourage further similar efforts. However, we believe that the Federal Register preamble confuses these helpful efforts with MSHA's duty to demonstrate the feasibility of its regulation. Of course, a realistic feasibility determination should have preceded the promulgation of the original regulation, and the agency's helpful, cooperative efforts are not a substitute for meeting its statutory mandates in that proceeding or in this one. In fact, the very need for these visits, and lab tests, and their outcome, prove that feasibility has not been demonstrated by MSHA.

MSHA's preamble recites a number of mine visits (68 Fed. Reg. at 48680-82). These visits support a conclusion that compliance with the 160 limit (and often the 400 limit) is not economically or technologically feasible in the vast majority of the industry. Specific comments regarding NMA and MARG Coalition Member mines are being prepared by those companies. In the interim, we provide the following information.

> (1) The vast majority of mine visits reported in the preamble (4 Martin Marietta sites, the Rogers Group Jefferson Mine, Nalley and Gibson's Georgetown Mine, Stone Creek Brick, Wisconsin Industrial Sand, and Governor Talc) do not report positive results nor support the proposition that compliance is feasible. The silence speaks loudly to the non-compliance status of those mines.
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> (2) The Federal Register discussion of the Carmeuse North America, Inc. Black River mine represents an excellent attempt to test bio diesel fuel. It fails to report, however, that the 50% bio-diesel presented insurmountable equipment problems and that the cost of bio-diesel has increased significantly, adversely impacting the feasibility potential of the 20% mixture. Additional information will be provided by Carmuese.

The preamble also describes lab testing of DPM filters by MSHA (68 Fed. Reg. at 48682), but these admirable efforts also prove that feasibility has not been demonstrated, and that work which should have been performed prior to the original rule, and is not yet complete.

(1) The discovery of filters which create NO_2 hazards to personnel is alarming and demonstrates the risks of rushing to regulate and mandating the use of unproven technology.

(2) The ongoing development and testing of paper or synthetic filter technology in the coal industry is encouraging but generally not applicable to the vast majority of engines in use in metal/nonmetal industry. Moreover, these filters generally are not warranted in mines with the potential for methane, since their massive ventilation quantities render their DPM levels the lowest in the industry (e.g. trona).

(2) The MSHA lab testing of filters is an excellent first step, but it does not render them feasible controls. In fact the NO_2 hazards discovered in attempted field applications demonstrate the risks of relying on lab tests or manufacturers representations of filter performance.

Lack Of A Valid Risk Assessment Mandates Deletion of the 160 Standard Now: Federal Register pages 48688-93 purports to identify scientific literature pertaining to health effects of "fine particles in general and DPM in particular," published after MSHA's Jan. 19.2001 rule. MSHA draws no conclusions from this simplistic listing of literature, nor should it. Like the original risk assessment, the literature does not support MSHA's exposure limits (400/160 TC, now EC), and the literature regarding "fine particles in general" is not even relevant to this proceeding. The included short summaries of "key results" would be insulting to the authors of the literature, and are neither accurate, neutral, nor supportive of MSHA's rule. For example, the summaries fail to include (i) potential and critical risk compounding factors, like smoking, (ii) exposure assessments to relate the studies to the population being regulated or (iii) the diesel component MSHA has chosen as a surrogate: carbon.

If the intent of this material is to provide bulk to give an appearance of scientific support, it fails to do so. Most importantly, the studies have nothing to do with elemental carbon (or total carbon), MSHA's chosen DPM surrogate, and the limit MSHA seeks to impose. More information on the MSHA risk assessment and the scientific literature is included in Dr. Borak's detailed review attached as Exhibit 1.

We again note that the Settlement Agreement created a "settlement limit" of 400, converted to Elemental Carbon, regardless of the lack of a valid, supporting risk assessment or a valid feasibility finding, in exchange for a corrections to that standard and a reevaluation of the validity of the 160 standard. This rulemaking not only provides the forum for that reevaluation, but MSHA's legislative mandates create the necessity for MSHA to act to delete the 160 limit in this rulemaking.

MSHA's Feasibility Interpretation Regarding the 400 Limit Is Flawed But MSHA's Own Conclusion Mandates Deletion Of The 160 Standard in This Rulemaking

At Fed. Reg. pages 48693-4, MSHA sets forth its interpretation of "feasibility" under the Mine Act and the case law. While the discussion is cast as a review of the law and the factors MSHA should consider in establishing feasibility, it is instead an advocacy piece for MSHA's conclusion: "[a]t this stage of the rulemaking, MSHA concludes that a permissible exposure limit of 308 micrograms.... is technologically feasible..." 68 Fed. Reg. at 48694. While independent mining engineering expert H. John Head will be submitting a feasibility review on our behalf before the end of the comment period, we can offer a number comments at this stage.

PATTON BOGGS LLP
ATTORNEYS AT LAW

First, MSHA only seems to pays lip service to the express language of it statute and loses its feasibility focus by reference to the legislative history and aspects of the case law. The express words of the Mine Act are clear in establishing the factors to be used in determining feasibility:

- research, demonstrations and experiments;
- latest available scientific data; and
- experience gained under this or other health and safety laws.

Of course, the opinion of the Supreme Court in the cotton dust case is the most important of the cases cited by MSHA and it defines feasible as: **"capable of being done, executed, or effected."** By focusing on everything except the Supreme Court's decision, and ignoring the express words of its own statute, MSHA reaches an erroneous feasibility decision.

MSHA again ignores that no other health and safety law or agency adopts or has proposed to adopt a DPM standard. Instead, OSHA and other agencies rely on the regulation of diesel exhaust gas, similar to those already in effect in the MSHA standards. Moreover, MSHA has not analyzed its own experience in regulating diesel gases to determine if they provide the protection it seeks. These factors alone demonstrate that MSHA has violated its statute in favor of a prejudged result, of a conflict of interest, that led to the original rule, on the last day of the last Administration.

MSHA concluded in the original rulemaking, as it does again now, that the technology for measuring the DPM standard is feasible. The conclusions are in stark contrast to the conclusions of Dr. Borak in Exhibit 4, the ever shifting and developing technology (e.g. 68 Fed. Reg. at 48695), the need to change the surrogate from total to elemental carbon, and the continuing changes in MSHA's sampling device and analysis procedures.

Moreover, MSHA disagrees with its statutorily designated research agency, NIOSH, which concludes that control technology "needs significant additional evaluation and some possible reengineering for underground mining applications." 68 Fed. Reg. at 48695. Instead of technology that is feasible, MSHA resorts to unsupported conclusions, like it did in the 2001 final rule: "Most mine operators can successfully resolve their implementation issues if they make informed decisions…." 68 Fed. Reg. at 48696.

We commend MSHA, however, for its acknowledgments that prior conclusions regarding feasibility were incorrect: "MSHA agrees that it may not be feasible to change engines on some diesel powered equipment." FR at 48696. This acknowledgement, however, is not factored into MSHA's determination of feasibility and is instead ignored in favor of statements encouraging equipment fleet replacement, without regard to the feasibility of such suggestions.

Similarly, we commend MSHA for acknowledging that: "ventilation system upgrades may not be the most cost effective DPM control for many mines, and for others, ventilation upgrades may be entirely impractical." We also commend MSHA for inspecting each mine subject to the rule over the last year and collecting "baseline" information. However, rather than quantify or identify which of the 175 mines subject to the rule are part of the "many" for which ventilation is not cost effective or those for which it is "entirely impractical," MSHA instead concludes, without data or support, that "for the majority of mines ventilation improvements would be an attractive DPM control option." 68 Fed. Reg. at 48700. Moreover, MSHA continues to rely on the Estimator to conclude feasibility, regardless of its now acknowledged incorrect assumptions on equipment appropriateness and performance for which it lacks actual knowledge or data.

Mining Engineer and diesel control expert H. John Head's report (Exhibit 5) concludes that the 160 limit is not feasible and that the 308 EC limit is not feasible for "significant percentage" of mining operations. He also concludes that MSHA's economic cost estimates and feasibility determination is wrong.

Most importantly, at 68 Fed. Reg. at 48705, MSHA admits that the 160 limit is not feasible:

> **[I]t would be infeasible for the metal and nonmetal mining industry to reach a lower interim limit.**

This acknowledgement is equally applicable to 2006, as it is to conditions today and MSHA does not provide any evidence to the contrary. This admission and the other comments contained herein provide MSHA with a mandate to delete the 160 limit now, in this rulemaking, under the provisions of the Mine Act and other laws, sanctioning only feasible standards based on sound, reproducible and transparent science. MSHA cannot mandate a limit to take effect in less than three years, based on pure speculation that feasible controls will appear miraculously, or speculation that the limit will provide health benefits, even though there is no evidence whatsoever to support such a conclusion.

The MARG Diesel Coalition appreciates the opportunity to comment on MSHA's proposed DPM rule and hopes that MSHA will act in accordance with its recommendations. For further information, contact Henry Chajet, Patton Boggs LLP, counsel to the MARG Diesel Coalition: 202-457-6511 or hchajet@pattonboggs.com.

Sincerely,

Henry Chajet

HC/eag

October 8, 2003

Mr. Marvin W. Nichols, Jr.
Director, Office of Standards, Regulations & Variances
MSHA
1100 Wilson Blvd.
Arlington, VA 22209-3939

Dear Mr. Nichols:

Enclosed with this letter are my updated comments on the Proposed Final Rule for Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners (*Fed Reg* 68:48668 *et seq*., August 14, 2003). I have also included copies of my three previous sets of comments and my current CV.

In preparing these comments, I considered whether recently published scientific reports have altered the opinions contained in my earlier comments. My updated review of the scientific literature confirms my prior opinion: the MSHA PELs are not scientifically supported.

Thank you for your considerations.

Yours truly,

Jonathan Borak, MD, DABT, FACP, FACOEM, FRCPC

cc: Hon. David Lauriski
Mr. Henry Chajet

Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners: Final Rule

Federal Register 66:5706-5910, 2001

Updated Comments of Jonathan Borak, MD

October 8, 2003

Over the past four years, I have submitted three sets of comments to MSHA concerning its proposed rules for Diesel Particulate Matter (DPM) in underground metal and nonmetal mines. This most recent proposal raises many of the same issues that I discussed in those previous comments. The most important of those issues remains the generally accepted fact that the scientific database is insufficient to sustain a meaningful quantitative risks assessment (QRA) for DPM. That view, which is supported by numerous authorities, should raise important concerns within the Agency because if data insufficiencies lead to an inability to perform scientifically correct QRA, then there is no scientific basis for the specific exposure levels that lie at the heart of the current proposal.

In my prior comments, I expressed the view that the Agency's permissible exposure limits (PELs) for diesel exhaust particulate (which MSHA earlier proposed to measure as total carbon and now proposes to measure as elemental carbon) are not supported by scientific evidence. My updated review of the scientific literature confirms my prior opinion: the MSHA PELs are not scientifically supported.

As described below, the deficiencies of that database noted previously by me (and others) persist undiminished. Likewise, QRA for diesel exhaust is as scientifically unjustified and unjustifiable today as it was in1998.

My earlier submissions essentially consisted of an initial set of comments followed by two sets of updates that each extended the underlying literature review by including ever more recent publications. Despite the growth in the size and number of contributions to that literature, the conclusions of the literature review were not fundamentally altered. Similarly, my current comments update that review, but find that there is no basis to change the original conclusion.

To allow these current comments to be brief, while also not ignoring important concerns to this rulemaking, I have attached my earlier comments as appendices. Rather than reiterating the earlier arguments, I will refer to them according to appendix and page. The contents of those Appendices are as follows:

> **Appendix A**: Comments of 7/28/98 by Jonathan Borak, MD and Howard Cohen, PhD, CIH, made on behalf of the National Mining Association.

Appendix B: Comments dated 7/21/99 by Jonathan Borak, MD, prepared as an addendum to earlier comments made on behalf of National Mining Association.

Appendix C: Comments of 11/05/01 by Jonathan Borak, MD and submitted to Hon. David Lauriski on behalf of the MARG Diesel Coalition.

1. Is Quantitative Risk Assessment for DPM Possible?

In my previous comments to MSHA, I detailed deficiencies of the scientific database and expressed concerns that that database was not adequate to perform quantitative risk assessment (QRA) for diesel particulate material (DPM).

Among the issues raised were these:

a) The original proposal contained a Risk Characterization for lung cancer that misrepresented key studies and neglected others that differed with or reached alternative conclusions than MSHA (Appendix A, pages 2-6);

b) MSHA ignored the generally-accepted evidence that animal models of DPM-induced lung cancer were not applicable to humans (Appendix A, pages 6-7);

c) The MSHA risk characterization wrongly relies upon the Healthy Worker Effect to explain reduced rates or lack of increased rates of lung cancer in DPM-exposed workers, rather than addressing such reduced or non-elevated cancer rates as suggesting the absence of adverse effects (Appendix C, pages 6-10);

d) The MSHA risk assessment is qualitative, not quantitative because it is not based on quantitative exposure measurements. (Appendix A, pages 11-13).

Although my specific concerns addressed risk assessment for DPM-related cancer, they also applied to non-cancer endpoints. In support of that view, I cited the 1999 report for the Health Effects Institute (1) that found a general lack of exposure data in the relevant epidemiological studies and concluded [see Appendix B, pages 7-8].
:

> "Only two such studies reported any quantitative exposure data associated in some manner with the occupational epidemiologic studies."

As I pointed out then, neither of those two considered miners. Moreover, the HEI Panel further concluded that one of those two was not suitable for QRA:

> "the railroad worker cohort study has very limited utility for QRA of lifetime lung cancer risk … the Panel recommends against using the current railroad worker data as the basis for QRA in ambient settings";

while the second had been insufficiently evaluated and was therefore of only limited value:

> "[It] may provide reasonable estimates of worker exposures to diesel exhaust, but significant further evaluation and development are needed."

Since then, there have been many debates, but essentially no new data have rectified that underlying data deficiency. For example, the just-published Proceedings of a Health Effects Institute workshop reached conclusions of even greater concern:

> "A principal limitation of epidemiologic studies of diesel exhaust exposure, whether of short-term or long-term effects, has been bias from potential exposure misclassification. Even in the occupational studies of workers exposed to diesel exhaust, exposure misclassification has been a substantial constraint in interpreting findings… Among the principal research issues are the following: - Is it possible to accurately measure diesel exposure so that quantitative estimates of the risk of lung cancer associated with diesel exposure can be made?" [(2), p. 4]

Likewise, Eric Garshick (principal author of the railroad worker study that is central to the MSHA risk assessment) presenting at that Health Effects Workshop, reiterated his public concerns that neither his own study nor any other was an adequate basis for quantifying the sort of dose-response necessary for QRA:

> "Although California has considered diesel exhaust to be a lung carcinogen with an estimable risk, this assessment is controversial. Given the lack of exposure measurements and an ill-defined linkage in the majority of these studies between job title and personal exposure …
>
> "Although current literature identifies diesel exhaust as a health hazard, insight into a dose-response relationship is limited by factors related to both cohort selection and exposure assessment. The development of an exposure model in the existing diesel exhaust epidemiologic literature is hindered by a lack of exposure measurements upon which an exposure model can be developed, uncertainty regarding the best measurement or marker(s) indicative of exposure, and uncertainty regarding historical exposures." [(3), p.17, 21]

That deficiency has been increasingly well recognized by others outside of MSHA. Of particular note is the 2002 USEPA *Health Assessment Document for*

Diesel Engine Exhaust (4). In that document, EPA concluded that the scientific database on DPM was too uncertain to sustain QRA:

> "…the available data are considered inadequate to confidently estimate a cancer unit risk…" (p. 8-11)
>
> "Because of uncertainty in the available exposure-response data, a cancer unit risk/cancer potency for diesel exhaust has not been derived" (p. 9-24).

Accordingly, EPA published only a weight-of-evidence risk assessment, not a QRA. Likewise, EPA could make no definitive assessment of non-cancer health effects:

> "Information from the available human studies is inadequate for a definitive evaluation of possible noncancer health effects from chronic exposure to diesel exhaust" [(5), p.35]

For presumably similar reasons, ACGIH recently withdrew its proposed threshold limit value (TLV) for diesel exhaust (6). That withdrawal is striking because more than 7 years had been spent in efforts to set a diesel exhaust TLV. During that time, three different proposed TLVs (an original proposal and two subsequent revisions) were listed on its Notice of Intended Changes. In light of those 7 years of effort and deliberation, the decision to withdraw, rather than revise, reflects the fundamental weakness of the scientific data needed to set a TLV, not lack of interest in its formulation.

Thus, the past two years has seen only confirmation that the DPM database is not sufficient to allow meaningful quantitative risk assessment. No new data have been added to the database that address those deficiencies.

2. Ultimate Carcinogens and Exposure Assessment

Beyond confirming the previously noted deficiencies of the underlying database, recent studies have evidenced other important data deficiencies that previously had not been well appreciated and that now heighten awareness of the difficulties of performing DPM exposure assessments necessary for QRA. A particular concerns involves determination of the appropriate exposure metric.

If DPM is a human carcinogen, then it should be expected to contain at least one specific carcinogenic agent. For various reasons, it seems almost certain that such a carcinogen would be found in the organic carbon (OC) fraction of DPM, rather than either the elemental carbon (EC) fraction or the gaseous volatiles.

Early rodent studies found that DPM, like carbon black and titanium dioxide, caused lung cancer in rats, but not other species. Such cancers have been attributed to 'dust overload', a physical process and mechanism of disease that is not believed to be relevant to humans (7-9). This argues that elemental carbon, essentially equivalent to carbon black, is not a potentially carcinogenic exposure in man. The Presidential Commission on Risk Assessment supports that view (10). Other studies found no evidence in rodents of lung cancer after exposure to the volatile gases in diesel exhaust (11). Thus that fraction seems also unlikely to pose cancer risks to humans. (See also Appendix A, pages 6-7).

On the other hand, the organic fraction of diesel exhaust contains specific, potentially mutagenic and carcinogenic agents, e.g., 3-nitrobenzanthrone and other nitro-PAH compounds. Recent studies have documented the presence of such agents in DPM and their activation by human enzyme systems (12,13). Likewise, DPM has been shown to upregulate cytochrome P450 1A1 (CYP1A1) leading to increased production of potentially mutagenic superoxide radicals (14). Commenting on their findings, the authors of the latter study made clear their view that PAHs, not elemental carbon were the active agents:

> "Judging from the previous reports and the present study, PAH in DPM should be responsible for the changes in these molecules and carbon nuclei of DPM are unlikely to influence the expression" (14).

Such data raise several concerns relevant to QRA.

First, if DPM exposure mediates a process leading to the formation of mutagenic oxide radicals and if that is the mechanism that leads to lung cancer, then DPM would best be described as a threshold carcinogen not amenable to linearized risk assessment models. The risk assessment models for DPM cited by MSHA rely on linearized models.

Second, and more generally, these findings suggest that if DPM exposure can cause human lung cancer, it is probably due to exposure to certain specific organic components. Most studies have not measured the organic fraction (organic carbon or OC) of DPM and none have attempted to measure the potential specific carcinogens. That failure would be of little consequence if OC exposure levels were closely related to levels of elemental carbon (EC) or total carbon (TC = EC + OC), the DPM measures that are most often reported. But, that relationship is not stable; measurements of EC and TC are now recognized as poor predictors of OC exposure. Because there are essentially no epidemiological data correlated to OC levels, and because EC and/or TC levels in such studies can not accurately predict OC, there are large and important uncertainties in the exposure assessments needed to sustain QRA. This can be restated simply: historical studies have used the wrong exposure metric for predicting lung cancer risks.

Over the past two years, an increasing number of publications have documented that EC and TC are poor estimators of OC. Much of that data has come from studies of miners. My colleagues and I published results of nearly 800 personal and area samples from seven US mines, documenting that the EC:TC ratio varied from 0.02 to 0.73, depending on the mine, location and total DPM air level (15). Similar large variability can be inferred from studies of Australian coal mines (see Tables II and III in (16)). Data similar to those that we reported were described in an HEI study of a US gold mine (17).

But miners are not the only workers for whom EC and TC are inappropriate proxy measures of OC. A 2002 study reported comparable variability of EC, OC and TC in the diesel exhaust from railroad locomotives (18). The authors of that study concluded:

> "In this study EC constituted a range of <1-75% of the TC in the locomotive cab" (18).

In addition, researchers at the California Air Resources Board have found that the EC:OC ratio varied markedly as a given engine was subjected to different standardized dynamometer test protocols (19). The proportion of EC in DPM varied from ≈20-80%, depending on engine cycle and test protocol.

The Health Effects Institute has also recently addressed and summarized these data:

> "measurements have shown that diesel PM emissions vary greatly in composition as a result of vehicle operating conditions, engine type, fuel properties, and maintenance... Variability in PM emissions results in variations in the source profiles and, in particular, in the relative amounts of EC, OC and ultrafine PM, and possibly specific markers... Diesel emissions contain varying amounts of OC and EC. They range in composition from 90% EC data high loads (very seldom are engines run at full load) to 90% OC at idle." [(2), p. 11]

Such findings have important implications. Cancer risk assessments are extrapolations derived from estimates of relevant dose-response relationships. If exposure metrics are uncertain, then resulting calculations of individual dose (derived from those exposure measures) must be uncertain as well. And if calculated doses are uncertain, then the corresponding dose-response curves, which can not be more accurate than measured dose, will be still more uncertain. But QRA, which rely on extrapolations rather than direct measurements, cannot be more certain than the dose-response data that defines them. Thus, uncertainty in exposure assessments leads to substantially greater uncertainty in any QRA that relies upon those assessments.

The MSHA risk assessment relies on exposure measures that are not good predictors of exposure to putative carcinogens. It is derived from measurements of EC or adjusted respiratory particulate (analogous to TC) measurements that are almost certainly not directly relevant to calculating lung cancer or other DPM health risks.

For such reasons, the MSHA risk assessment cannot be defended: it is based on the wrong exposure metric and, therefore, is not consistent with standard risk assessment practices. This conclusion, which is consistent with my earlier comments, is also consistent with the recent conclusions of the Health Effects Institute and USEPA, who argue that the current DPM database is insufficient for QRA.

MSHA should join with other responsible agencies and advisory groups by acknowledging the scientific limitations of the current DPM database for QRA, rather than forcing adoption of exposure limits that purport to be derived from a risk assessment that is scientifically indefensible.

3. Revision of the Teamsters' Exposure Assessment

In a just published report (20), Bailey et al presented a 'refinement' of the exposure assessment that was earlier utilized for QRA on lung cancer mortality in truck drivers by Steenland et al (21). This 'refinement' was a response to criticisms raised by the Health Effects Institute and others regarding the exposure assessment employed in that QRA. Although presented as an effort to address uncertainties, this effort does not clarity the issues. Among its deficiencies are the following:

a). Bailey et al accepts that there are important alternative sources of EC: "Recent studies have shown that gasoline vehicle exhaust is responsible for a substantial portion of ambient EC". In the present study, they assumed that the <u>average proportion of EC due to diesel</u> in the Steenland et al study was 59%. But, that study relied on a 1991 exposure survey by Zaebst et al (22), which did not provide data necessary to determine that value. Instead, Bailey et al have relied on data from other locations and times. Whether this approximation is correct (and whether it is correctly described as a beta distribution) is not directly testable or knowable.

b) A similar uncertainty involves the authors' assumption that on average, EC represents 63% of DPM by weight. That number is derived from a pooling of data from various recent studies of truck emissions. Preliminary data from California Air Resources Board indicates that the EC:TC ratio can vary widely depending on engine load, fuel type and test protocols. I also suspect that performance of older diesel engines was measurably different from that of more recent engines. Whether 63% is a correct figure for purposes of refining the Steenland et al risk assessment is not directly testable or knowable.

c). A key issue in the historical reconstruction of the Teamsters DPM exposure assessment concerns the rate of dieselization of heavy-duty trucks. Bailey et al back-extrapolated exposures to 1937 and assumed that the rate of dieselization was linear from 1937 to 1963. It is my understanding from the engine manufacturers that this is a very unrealistic assumption and not justifiable because the sharpest rate of increase was associated with creation of the national highway system in response to Eisenhower administration programs of the 1950s. From their perspective, this invalidates the study.

For several reasons, this report has no immediate impact on the risk assessment presented in the MSHA Proposed Rule.

a). The study is based on erroneous assumptions. Therefore, it is not clear that it has improved the accuracy of the prior exposure estimate.

b). Bailey et al explicitly acknowledge that 40-50% of measured EC is from other sources, mainly gasoline engines. They also acknowledge that EC is probably a marker of exposure, rather than being the "carcinogen":

> "EC is the core of diesel particulate and is the carrier of condensable organic material that is also emitted. The organic fraction of DPM includes a range of organic species … a number of these organic species are carcinogenic… however the mechanism of injury associated with DPM is not currently known".

EC is also the marker of exposure from gasoline engines, and the exhaust from gasoline engines also contains potential carcinogens.

c). There is no *a priori* reason to assume that if lung cancers were increased among truck drivers, then that increase would be due to the non-EC fraction of DPM, rather than the non-EC fraction of gasoline engines. And, to the extent that EC exposure is a metric of miles driven or hours "on the road", it would be expected to be a covariate of any other carcinogenic exposures that were associated with miles driven or hours "on the road".

d). The study itself does not comment on exposures among miners or in underground mines. Likewise, it is not clear that these data are useful for specifically calculating lung cancer risk among miners.

Thus, it is my opinion that the recent report by Bailey et al is a flawed effort to refine the reconstruction of historical exposure among truck drivers who died in 1983. It is not directly relevant to exposures in miners or exposures in mines. It is not a risk assessment and it has no immediate impact on estimation of the carcinogenic potency of diesel particulate.

4. Human Health Data in the Final Rule

The "preamble" discussion and health effects literature cited in the proposed Final Rule present no additional or new data relevant to the human health risks of DPM. Accordingly, there is nothing in the Federal Register notice of the proposed Final Rule that alters my original opinions.

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Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners: Final Rule
Federal Register 66:5706-5910, 2001
Comments on Sampling Variability and Errors

Jonathan Borak, MD, DABT
Greg Sirianni, MS

October 13, 2003

NIOSH and MSHA have independently published methods by which they determine acceptable parameters for the application of analytical methods for compliance purposes. Their respective approaches are discussed below, followed by the findings of our reanalyses of MSHA and MARG DPM data in light of those two methods for determining acceptability of analytical methods.

1. NIOSH Method and the 5040 Method

NIOSH considers both the accuracy and the precision of a test when considering its acceptability as an analytical method.

> Accuracy refers to the difference between a measured concentration and the 'true' concentration of the sample that has been measured. The difference between the average of measured values and the 'true' value is sometimes referred to as bias.
>
> Precision refers to the amount of random variation of the method about its own mean, i.e. the "tightness" of the clustering of results.

For EC measurements using the NIOSH 5040 Method, there is no 'suitable reference material' against which analytical results can be compared. Thus, it is not possible to determine analytical 'accuracy'. Accordingly, acceptability of the method has rested only on an assessment of its 'precision'.

NIOSH evaluates the 'precision' of analytical methods in terms of its coefficient of variation (CV). The CV, a widely used index of the dispersion of distribution of data, is calculated as the standard deviation of a distribution divided by the distribution mean: CV = SD ÷ mean. The CV is usually reported as a percentage: CV (%) = [SD ÷ mean] x 100. With relation to the mean of a distribution, 95% of the distribution is expected to be found within the range defined as ±1.96 CV.

NIOSH Guideline for evaluating an analytical method state that the CV of an analytical method must be ≤12.76% (i.e., 25% ÷ 1.96 = 12.76)"

> "Specifically, the goal of this evaluation is to determine whether, on average, over a concentration range of 0.1 to 2 times the exposure limit, the method can provide a result that is within ±25% of the true concentration 95% of the time." (1)

Implicit in this criterion is the assumption that the mean of the distribution of analytical results will coincide with the "true concentration ... represented by an independent method" (1), but there is no "independent method" for measurement of EC and there is no suitable reference material.

The NIOSH documentation for the 5040 Method indicates that precision was determined in two ways (2):

> 1) Precision was determined in the field setting of a loading dock where a diesel truck was operating. There were 14 short-duration, low-volume samples (30 min x 2 L/min = 60 L; two each of seven different sampler types) with a CV of 5.6% calculated on the basis of the mean of those samples (i.e., not an independently determined "true concentration"). The amount of EC collected (240 µg/sample = 28.1 µg/cm^2) was calculated by NIOSH as equivalent to sampling an EC level of 250 µg/m^3 for 8 hours at 2 L/min.
>
> 2) Precision was also determined in a laboratory where diesel particles were generated with a dilution tunnel and a dynamometer. Four EC concentrations, from 23 to 240 µg/m^3 were generated (the intermediate levels were not described). The numbers of samples at each concentration were not described. Variance was proportional to concentration, thus precision increased with increasing concentration. "Pointwise accuracy" was ± 16.7% at the lowest loading (23 µg/m^3), while the overall precision (CV) was 8.5%. Precision at exposures of 100-150 µg/m^3 was not reported.

It is notable that neither of these determinations of precision was performed in a mining environment and neither utilized the proposed sampling method using a sub-micron impactor.

2. MSHA Method and the 5040 Method

MSHA uses a related, but different approach for considering the acceptability of an analytical method. With respect to the Proposed Final Rule for DPM, it states:

> "MSHA would issue a citation only if measurement demonstrated noncompliance with at least a 95-percent confidence. We would achieve this 95-percent confidence by comparing each EC measurement to the limit multiplied by an appropriate "error factor... The formula for the error

factor was based on three factors included in the DPM settlement agreement…" (3).

The MSHA website provides a technical document describing the Standard Error Factor for TC Analysis (4) which states:

"As with all other exposure-based M/NM compliance determinations, MSHA will address uncontrollable sampling and analytical errors (SAE) by allowing a margin of error before issuing a citation for exceeding the total carbon (TC) limit".

The DPM error factor is comprised of three components.

CV_P = Variability in volume of air pumped through the filter

CV_D = Variability in area of dust deposited on filter

CV_A = Analytical measurement imprecision

The Standard Error Factor (EF) is then calculated as:

$$EF = 1 + [1.645 \times (CV_P^2 + CV_D^2 + CV_A^2)^{0.5}]$$

The numerical value "1.645" corresponds to the number of standard deviations (SD) above the mean of a normal distribution that defines that point in the distribution above which there is 5% of the distribution. In statistical terms, the value "1.645 x SD" defines the upper bound for a 95-percent confidence range ("95-percent 1-tailed confidence coefficient") using a one-tailed statistical test.

By means of calculations detailed in the technical document, MSHA presents the following values for the three components of its EF:

CV_P = 0.042

CV_D = 0.031

CV_A = 0.046 (for EC $\geq$308 μg/m^3).

CV_A = 0.072 (for EC $\geq$123 μg/m^3)

By substituting those components into the equation, MSHA calculates the following two EF, one appropriate for the interim PEL:

$$EF = 1 + [1.645 \times (0.042^2 + 0.031^2 + 0.046^2)^{0.5}]$$

$$EF = 1 + (1.645 \times 0.0696)$$

$$\mathbf{EF = 1.12}$$

For the final PEL, the calculated EF is **1.15**.

3. MARG Study Data

In the MARG DPM study, we obtained personal and area samples from seven non-metal mines with results determined using the NIOSH 5040 Method (5). There were 25 area baskets (4 or 5 samplers per basket) for which at least one EC measurement was in the range 75-200 μg/m³. Analytical data from those baskets are shown in Appendix Table 1, which presents the range, mean, standard deviation and CV for each of the baskets. Those data are summarized in Table 1a, which indicates the number and proportion of baskets corresponding to CV ranges of 0-4.99, 5-9.99, >10 and >12.5%.

Table 1a: Summary of Coefficient of Variation Data for 25 Area Baskets - 4 or 5 samplers per basket - at least one sample in 75-200 μg/m³ range - MARG Diesel Study

CV	0-4.99	5-9.99	>10	>12.5
# of Samples	5/25	7/25	13/25	8/25
% of Samples	20%	28%	52%	32%

4. MSHA Sampling Data

MSHA has apparently not published data that independently calculates the CV of the NIOSH 5040 Method as used in mines. However, two sampling data sets have been provided to the public that allow a comparison of the results when two punches are taken from the same filter (although not necessarily measured by the same laboratory). In its technical document (discussed above), MSHA indicates that analytical differences between punches taken from the same sample filter are a component of Analytical Measurement Imprecision (CV_A).

One data set, the Compliance Assistance Database, contained 223 pairs of punch-repunch data from samples collecting using an older version of the SKC impactor that differs from the impactor proscribed in the proposed Final Rule. The data are presented in Appendix Table 2. The table columns indicate: Sample ID #, EC in punch 1, EC in punch 2, Absolute Difference (Absolute Δ) and Percentage Difference (% Δ). Most of the samples with punch-repunch data had EC values >300 μg/m³, but there were 22 samples (9.9%) with values <200 μg/m³.

Table 2a summarizes the data set, indicating the number and proportion of samples with punch-repunch differences corresponding to 0-4.99, 5-9.99, >10 %.

Table 2a: Summary of Punch-Repunch Data for 223 EC Samples - Compliance Assistance Database

% Difference (μg/m^3)	0-4.99%	5-9.99%	>10
# of Samples	190/223	20/223	13/223
% of Samples	85.2%	9.9%	5.8%

Table 2b summarizes the data for samples <200 μg/m^3.

Table 2b: Summary of Punch-Repunch Data for 22 EC Samples < 200 μg/m3 -- Compliance Assistance Database

% Difference (μg/m^3)	0-4.99%	5-9.99%	>10
# of Samples	17/22	3/22	2/22
% of Samples	77.3%	13.6%	9.1%

A second set of sampling data were provided to us and identified as from the 31-Mine study. That database contained 63 samples for which there were punch-repunch analytical differences. Those data are presented in Appendix Table 3. The table columns indicate: Sample ID #, EC in punch 1, EC in punch 2, Absolute Difference (Absolute Δ) and Percentage Difference (% Δ). We understand that the punch-repunch samples were analyzed at different labs.

Table 3a summarizes the data set, indicating the number and proportion of samples with punch-repunch differences corresponding to 0-4.99, 5-9.99, >10 %.

Table 3a: Summary of Punch-Repunch Data for 63 EC Samples - (Identified as '31-Mine Study')

% Difference (μg/m^3)	0-4.99%	5-9.99%	>10
# of Samples	36/63	17/63	10/63
% of Samples	57.1%	27.%	15.8%

Table 3b summarizes the data for samples <200 μg/m^3.

Table 3b: Summary of Punch-Repunch Data for 52 EC Samples <200 μg/m^3 - (Identified as '31-Mine Study')

% Difference (μg/m^3)	0-4.99%	5-9.99%	>10
# of Samples	27/52	15/52	10/52
% of Samples	51.9%	28.8%	19.2%

5. Discussion

Based on the data analyzed above, we conclude that that the Error Factor (EF) presented in the proposed Final Rule is too small. In the MARG study, 32% of baskets containing at least one sample in the 75-200 μg/m^3 range had a CV ≥12.5 %. That finding is inconsistent with the NIOSH criteria for appropriateness of analytical methods and does not meet guidelines presented in the proposed Final Rule.

With respect to MSHA, its EF is calculated on the assumption that CV_A, of which one component is punch-repunch differences, will be less than 4.6% for samples in which EC ≥308 μg/m^3 and less than 7.2% for samples in which EC ≤123 μg/m^3. But data from the two MSHA databases indicate that punch-repunch differences often exceed the total value of CV_A, thus indicating that the formula for EF underestimates the actual imprecision of the MSA method. Moreover, the punch-repunch differences were greater than the total EF in 4.5% of the samples with punch-repunch data in the Compliance Assistance database and 9.5% of such samples in the 31-Mine database. Accordingly, it is almost certain that both of those databases document failure to meet the NIOSH and MSHA acceptability criteria.

It is unfortunate that MSHA has not evaluated its proposed method by means of systematic determinations of the CV for samples obtained under real mining settings. Lacking such data, it does not seem possible to conclude whether the proposed sampling methods and their related PELs meet the NIOSH and MSHA appropriateness criteria discussed above. As a result, there is an apparent failure to demonstrate feasibility of the proposed method despite the Agency's two databases, which raise significant concerns about the methods proposed in the Final Rule.

6. References

1. National Institute for Occupational Safety and Health: Occupational Exposure Sampling Strategy Manual (NIOSH Publication No. 77-173). Washington, DC: U.S. Department of Health, Education and Welfare, 1977.

2. National Institute for Occupational Safety and Health. Elemental Carbon (Diesel Particulate) (5040) (Issue 3). In: NIOSH Manual of Analytical Methods, Cincinnati: National Institute for Occupational Safety and Health, 1999.

3. Mine Safety and Health Administration: 30 CFR Part 57: Diesel particulate matter exposure of underground metal and nonmetal miners; Proposed rule. Fed Reg 67:48668-48721, 2003.

4. Mine Safety and Health Administration: Metal and Nonmetal Diesel Particulate Matter (DPM) Standard Error Factor for TC Analysis. available at: http://www.msha.gov/01%2D995/dieselerrorfactor.doc, 2003.

5. Cohen HJ, Borak J, Hall T, et al: Exposure of miners to diesel exhaust particulates in Underground Nonmetal Mines. Am Ind Hyg Assoc J 63:651-658, 2002.

Appendices:

Data Tables 1-3

Table 1: Coefficient of Variation of Area Baskets - 4 or 5 samplers per basket - at least one sample in 75-200 μg/m³ range - MARG Diesel Study {21286}

Range of EC: ($\mu g/m^3$)	Mean EC:	Std. Dev:	CV:
125 - 134	128	4	3.4
77 - 82	79	2	2.6
160 - 205	190	21	11.3
142 - 223	181	34	18.7
41 - 83	58	22	38.1
71 - 110	91	19	20.3
63 - 77	69	7	10.1
85 - 97	92	6	6.3
153 - 232	211	33	15.6
163 - 235	201	36	17.9
94 - 119	112	10	9.1
88 - 122	105	14	13.3
152 - 199	174	19	10.9
80 - 118	102	17	16.3
95 - 117	107	11	10.0
155 - 182	168	10	5.8
144 - 165	154	10	6.7
131 - 155	139	10	7.6
99 - 112	105	7	6.3
140 - 152	146	5	3.3
126 - 132	130	3	2.3
117 - 123	120	3	2.0
83 - 99	91	11	12.4
94 - 110	105	7	7.1
69 - 100	91	13	13.9

Table 2. Punch-Repunch Data for 223 EC Samples - Compliance Assistance Database

N	Sample ID	EC_1 (μg/m3)	EC_2 (μg/m3)	Absolute Δ	% Δ
1	SKC0005656	365	368	3.63	1.00
2	SKC0006230	120	123	3.20	2.66
3	SKC0006262	577	581	3.34	0.58
4	SKC0006266	372	385	12.79	3.44
5	SKC0006267	621	632	10.90	1.75
6	SKC0006270	442	431	10.75	2.44
7	SKC0006272	447	458	10.75	2.40
8	SKC0006274	774	776	1.89	0.24
9	SKC0006276	485	482	3.34	0.69
10	SKC0006277	538	512	26.44	4.91
11	SKC0006279	556	562	6.68	1.20
12	SKC0006280	502	510	8.28	1.65
13	SKC0006281	642	642	0.58	0.09
14	SKC0006286	392	409	16.85	4.30
15	SKC0006293	467	480	13.22	2.83
16	SKC0006323	556	554	2.32	0.42
17	SKC0006325	435	460	24.70	5.67
18	SKC0006333	397	397	0.44	0.11
19	SKC0006346	643	649	6.10	0.95
20	SKC0006397	637	668	30.37	4.76
21	SKC0006398	636	639	3.05	0.48
22	SKC0006401	590	586	4.07	0.69
23	SKC0006407	676	684	7.56	1.12
24	SKC0006410	1043	1053	10.03	0.96
25	SKC0006411	571	568	3.49	0.61
26	SKC0006414	583	584	1.31	0.22
27	SKC0006423	670	651	19.03	2.84
28	SKC0006424	547	551	3.34	0.61
29	SKC0006426	808	814	5.96	0.74
30	SKC0006442	354	369	15.69	4.44
31	SKC0006443	394	380	14.09	3.58
32	SKC0006444	460	456	3.63	0.79
33	SKC0006449	941	756	184.81	19.64
34	SKC0006450	190	168	21.94	11.54
35	SKC0006460	479	472	6.68	1.40
36	SKC0006462	644	594	50.71	7.87
37	SKC0006463	708	690	18.02	2.54
38	SKC0006466	582	610	27.46	4.71
39	SKC0006511	799	795	4.50	0.56
40	SKC0006518	591	564	27.17	4.60
41	SKC0006520	718	722	3.78	0.53
42	SKC0006526	372	346	25.72	6.92
43	SKC0006527	616	604	11.77	1.91
44	SKC0006528	584	571	12.35	2.12
45	SKC0006535	565	571	6.83	1.21

N	Sample ID	EC_1 (μg/m3)	EC_2 (μg/m3)	Absolute Δ	% Δ
46	SKC0006536	838	757	80.64	9.63
47	SKC0006537	566	653	86.74	15.33
48	SKC0006539	392	417	25.28	6.45
49	SKC0006540	159	160	0.58	0.36
50	SKC0006566	603	614	11.33	1.88
51	SKC0006567	358	351	7.41	2.07
52	SKC0006568	571	523	48.09	8.42
53	SKC0006576	559	570	10.61	1.90
54	SKC0006579	786	704	82.24	10.46
55	SKC0006580	300	298	1.74	0.58
56	SKC0006581	697	697	0.29	0.04
57	SKC0006582	566	553	13.22	2.33
58	SKC0006583	1098	1086	12.50	1.14
59	SKC0006588	452	450	2.32	0.51
60	SKC0006634	374	370	4.65	1.24
61	SKC0006635	393	390	3.34	0.85
62	SKC0006637	663	650	13.08	1.97
63	SKC0006644	381	379	1.60	0.42
64	SKC0006649	134	160	26.44	19.74
65	SKC0006651	197	201	4.50	2.29
66	SKC0006996	764	732	32.26	4.22
67	SKC0006998	254	257	3.63	1.43
68	SKC0006999	431	408	22.52	5.23
69	SKC0007000	634	634	0.44	0.07
70	SKC0007001	589	557	32.40	5.50
71	SKC0007003	614	623	8.72	1.42
72	SKC0007004	363	362	0.87	0.24
73	SKC0007007	388	377	11.77	3.03
74	SKC0007008	399	383	16.85	4.22
75	SKC0007013	522	520	1.89	0.36
76	SKC0007014	494	473	20.34	4.12
77	SKC0007020	442	446	3.49	0.79
78	SKC0007030	303	299	4.36	1.44
79	SKC0007036	436	417	19.18	4.39
80	SKC0007038	1147	1147	0.73	0.06
81	SKC0007039	540	457	83.54	15.46
82	SKC0007040	707	700	6.97	0.99
83	SKC0007041	1132	1189	57.39	5.07
84	SKC0007044	926	967	41.12	4.44
85	SKC0007048	374	384	10.32	2.76
86	SKC0007049	638	649	11.04	1.73
87	SKC0007050	1113	1098	15.55	1.40
88	SKC0007056	380	372	7.56	1.99
89	SKC0007057	487	472	14.67	3.01
90	SKC0007059	428	435	6.83	1.59
91	SKC0007084	468	453	14.53	3.11
92	SKC0007289	445	428	17.14	3.85
93	SKC0009168	461	428	32.69	7.09
94	SKC0009173	72	69	3.49	4.82

N	Sample ID	EC_1 (μg/m3)	EC_2 (μg/m3)	Absolute Δ	% Δ
95	SKC0009192	383	386	3.63	0.95
96	SKC0009249	441	435	6.25	1.42
97	SKC0009256	415	421	5.81	1.40
98	SKC0009263	548	545	3.34	0.61
99	SKC0009287	70	67	3.05	4.34
100	SKC0009306	370	396	25.86	6.99
101	SKC0009311	192	197	4.65	2.42
102	SKC0009338	380	391	10.90	2.86
103	SKC0009347	681	666	14.38	2.11
104	SKC0009349	679	656	22.96	3.38
105	SKC0009350	677	663	13.80	2.04
106	SKC0009354	883	861	21.21	2.40
107	SKC0009362	434	419	15.55	3.58
108	SKC0009364	475	481	5.52	1.16
109	SKC0009365	108	113	5.09	4.69
110	SKC0009371	571	563	8.57	1.50
111	SKC0009372	646	636	10.32	1.60
112	SKC0009374	548	541	6.39	1.17
113	SKC0009380	720	727	7.12	0.99
114	SKC0009381	594	600	6.39	1.08
115	SKC0009383	827	836	8.86	1.07
116	SKC0009390	271	275	4.36	1.61
117	SKC0009392	752	772	19.91	2.65
118	SKC0009399	536	519	17.14	3.20
119	SKC0009404	446	437	9.15	2.05
120	SKC0009406	578	589	11.04	1.91
121	SKC0009407	409	400	9.59	2.34
122	SKC0009409	520	460	59.57	11.46
123	SKC0009420	348	368	20.05	5.76
124	SKC0009427	478	474	3.92	0.82
125	SKC0009432	222	219	3.05	1.38
126	SKC0009435	256	260	3.78	1.47
127	SKC0009436	253	253	0.44	0.17
128	SKC0009442	255	255	0.15	0.06
129	SKC0009444	440	431	9.30	2.11
130	SKC0009453	422	427	4.79	1.14
131	SKC0009456	447	473	25.86	5.79
132	SKC0009474	221	226	5.09	2.30
133	SKC0009479	191	195	3.78	1.98
134	SKC0009511	412	400	12.35	2.99
135	SKC0009514	395	406	11.48	2.91
136	SKC0009521	125	126	1.31	1.05
137	SKC0009522	95	95	0.29	0.31
138	SKC0009527	616	606	10.46	1.70
139	SKC0009569	360	385	24.85	6.89
140	SKC0009593	204	207	3.34	1.64
141	SKC0009613	39	41	1.45	3.72
142	SKC0009631	594	590	4.65	0.78

N	Sample ID	EC_1 (μg/m3)	EC_2 (μg/m3)	Absolute Δ	% Δ
143	SKC0009638	595	602	6.83	1.15
144	SKC0009640	496	471	24.85	5.01
145	SKC0009644	596	600	3.92	0.66
146	SKC0009656	830	813	16.42	1.98
147	SKC0009659	539	524	14.82	2.75
148	SKC0009668	133	134	1.45	1.09
149	SKC0009675	483	481	1.89	0.39
150	SKC0009676	493	485	8.43	1.71
151	SKC0009681	391	404	12.93	3.31
152	SKC0009682	949	932	17.58	1.85
153	SKC0009684	498	492	5.81	1.17
154	SKC0009718	963	887	75.70	7.86
155	SKC0009724	975	967	8.14	0.83
156	SKC0009725	221	211	10.17	4.60
157	SKC0009830	602	524	78.75	13.07
158	SKC0009839	605	605	0.29	0.05
159	SKC0009858	924	946	22.38	2.42
160	SKC0009863	484	478	6.25	1.29
161	SKC0009864	482	482	0.44	0.09
162	SKC0009871	465	495	29.79	6.40
163	SKC0009874	908	875	33.85	3.73
164	SKC0009875	652	671	19.61	3.01
165	SKC0009877	497	495	1.89	0.38
166	SKC0009912	526	522	3.20	0.61
167	SKC0009922	611	618	6.68	1.09
168	SKC0009925	1114	985	129.89	11.66
169	SKC0009929	868	870	2.32	0.27
170	SKC0009931	1172	1137	35.02	2.99
171	SKC0009934	782	767	14.67	1.88
172	SKC0009947	965	1002	37.05	3.84
173	SKC0009960	874	1119	245.55	28.11
174	SKC0009964	780	785	4.50	0.58
175	SKC0009969	1203	1212	8.28	0.69
176	SKC0009970	736	770	33.85	4.60
177	SKC0009973	514	518	4.50	0.88
178	SKC0009977	163	163	0.15	0.09
179	SKC0009983	98	97	1.31	1.34
180	SKC0009988	186	168	18.16	9.78
181	SKC0009991	698	689	9.44	1.35
182	SKC0009996	354	345	9.44	2.67
183	SKC0010005	123	125	1.31	1.06
184	SKC0010007	494	512	18.02	3.64
185	SKC0010021	525	536	11.04	2.10
186	SKC0010022	557	543	14.24	2.56
187	SKC0010024	433	429	4.50	1.04
188	SKC0010028	1020	1158	137.74	13.50
189	SKC0010033	405	388	16.71	4.13
190	SKC0010039	322	327	4.94	1.53

N	Sample ID	EC_1 (µg/m3)	EC_2 (µg/m3)	Absolute Δ	% Δ
191	SKC0010051	491	503	12.06	2.45
192	SKC0010064	132	125	7.41	5.60
193	SKC0010076	363	366	3.20	0.88
194	SKC0010087	53	51	2.03	3.86
195	SKC0010097	379	377	2.47	0.65
196	SKC0010104	575	557	17.44	3.03
197	SKC0010122	166	176	10.32	6.22
198	SKC0010127	565	569	4.50	0.80
199	SKC0010131	399	404	4.65	1.17
200	SKC0010164	290	300	9.15	3.15
201	SKC0010227	498	497	0.87	0.18
202	SKC0010260	503	500	2.76	0.55
203	SKC0010263	972	987	15.11	1.55
204	SKC0010264	320	323	3.05	0.95
205	SKC0010283	615	630	14.24	2.31
206	SKC0010285	1448	1149	299.45	20.68
207	SKC0010294	653	675	22.96	3.52
208	SKC0010300	485	489	3.92	0.81
209	SKC0010304	1463	1500	37.05	2.53
210	SKC0010309	427	445	18.02	4.22
211	SKC0010310	900	891	8.72	0.97
212	SKC0010338	223	227	3.92	1.76
213	SKC0010388	384	393	8.43	2.19
214	SKC0010402	379	381	2.03	0.54
215	SKC0010502	199	197	1.60	0.80
216	SKC0010514	365	359	5.67	1.55
217	SKC0010526	439	445	5.81	1.32
218	SKC0010539	1372	1144	228.26	16.64
219	SKC0010571	456	466	9.59	2.10
220	SKC0010590	961	965	4.79	0.50
221	SKC0010609	662	658	4.21	0.64
222	SKC0010642	505	502	2.47	0.49
223	SKC0010644	668	667	1.74	0.26

N	Sample ID	EC_1 (µg/m3)	EC_2 (µg/m3)	Absolute Δ	% Δ
	Min	39	41	0.15	0.04
	Max	1463	1500	299.45	28.11
	Avg	535	531	18.26	3.08
	St.Dev	258	252	36.01	3.90
	CV	0.48	0.48	1.97	1.27

Table 3: Punch-Repunch Data for 63 EC Samples - DPM2 Database

N	Sample ID	Punch A (ug/m3)	Punch B (ug/m3)	AbsoluteΔ	% Δ
1	SKC-1D-169	23.10	23.68	0.58	2.52
2	SKC-1D-174	93.28	98.51	5.23	5.61
3	SKC-1D-166	2.62	4.94	2.32	88.89
4	SKC-1D-161	46.06	57.10	11.04	23.97
5	SKC-1D-162	136.72	143.11	6.39	4.68
6	SKC-1D-171	45.04	45.77	0.73	1.61
7	SKC-1D-173	23.39	23.97	0.58	2.48
8	SKC-1D-170	42.86	46.20	3.34	7.80
9	SKC-1D-168	4.94	5.09	0.15	2.94
10	SKC-1D-164	11.04	13.80	2.76	25.00
11	SKC-1D-155	59.86	64.37	4.50	7.52
12	SKC-1D-158	15.84	15.98	0.15	0.92
13	SKC-1D-175	14.97	16.42	1.45	9.71
14	SKC-1D-176	15.11	16.13	1.02	6.73
15	SKC-1D-172	120.74	127.42	6.68	5.54
16	SKC-1D-157	18.89	21.21	2.32	12.31
17	SKC-1D-160	24.85	25.14	0.29	1.17
18	SKC-1D-167	28.91	29.49	0.58	2.01
19	SKC-01-512	58.41	59.13	0.73	1.24
20	SKC-01-514	70.61	75.99	5.38	7.61
21	SKC-01-518	85.87	92.41	6.54	7.61
22	SKC-01-521	36.32	37.20	0.87	2.40
23	SKC-01-513	125.24	128.59	3.34	2.67
24	SKC-01-515	72.79	75.99	3.20	4.39
25	SKC-01-516	81.22	83.54	2.32	2.86
26	SKC-01-517	84.27	87.47	3.20	3.79
27	SKC-01-520	66.25	66.54	0.29	0.44
28	SKC-01-532	151.69	159.10	7.41	4.89
29	SKC-01-528	79.48	80.06	0.58	0.73
30	SKC-01-523	207.19	215.47	8.28	4.00
31	SKC-01-524	190.34	192.95	2.62	1.37
32	SKC-01-525	74.83	79.48	4.65	6.21
33	SKC-01-526	60.88	67.13	6.25	10.26
34	SKC-01-527	116.96	123.65	6.68	5.71
35	SKC-0005345	57.54	58.55	1.02	1.77
36	SKC-0005346	53.76	56.81	3.05	5.68
37	SKC-0005347	62.19	64.80	2.62	4.21
38	SKC-0005348	53.47	58.26	4.79	8.97
39	SKC-0005349	58.41	61.31	2.91	4.98
40	SKC-0005350	53.03	54.05	1.02	1.92
41	SKC-0005351	35.31	38.21	2.91	8.23
42	SKC-0005352	10.32	15.55	5.23	50.70
43	SKC-0005353	11.77	13.08	1.31	11.11
N	Sample ID	Punch A (ug/m3)	Punch B (ug/m3)	AbsoluteΔ	% Δ
44	SKC-0005354	9.59	10.46	0.87	9.09

45	SKC-0005272	96.18	99.82	3.63	3.78
46	SKC-0005273	100.69	103.01	2.32	2.31
47	SKC-0005274	120.59	122.05	1.45	1.20
48	SKC-0005275	74.68	74.68	0.00	0.00
49	SKC-0005276	132.22	132.94	0.73	0.55
50	SKC-0005277	35.45	37.92	2.47	6.97
51	SKC-0005278	27.46	31.53	4.07	14.81
52	SKC-0005279	23.10	28.33	5.23	22.64
53	SKC-0005189	138.76	153.72	14.97	10.79
54	SKC-0005190	560.98	568.54	7.56	1.35
55	SKC-0005191	1483.02	1539.97	56.96	3.84
56	SKC-0005192	669.95	699.74	29.79	4.45
57	SKC-0005193	338.54	364.98	26.44	7.81
58	SKC-0005195	426.15	426.87	0.73	0.17
59	SKC-0005187	289.14	293.78	4.65	1.61
60	SKC-0005197	874.53	883.82	9.30	1.06
61	SKC-0005196	399.12	416.70	17.58	4.40
62	SKC-0005198	1410.37	1419.81	9.44	0.67
63	SKC-0005199	1548.25	1676.84	128.59	8.31
	Min	2.62	4.94	0.00	0.00
	Max	1548.25	1676.84	128.59	88.89
	Mean	181.67	189.03	7.37	7.63
	St. Dev.	333.99	347.57	17.75	12.99
	CV	1.84	1.84	2.41	1.70

TECHNICAL AND ECONOMIC FEASIBILITY OF DPM REGULATIONS

Prepared for:

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MACTEC Project No. 551102,0100

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October 13, 2003

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Executive Summary

MACTEC Engineering & Consulting, Inc. (MACTEC) was retained by the MARG Diesel Coalition (MARG), in conjunction with the National Mining Association (NMA) and the National Stone Sand and Gravel Association (NSSGA) to undertake an assessment of the technical and economic feasibility of the Diesel Particulate Matter (DPM) Exposure Rule for Underground Metal and Nonmetal Miners.

MARG, NMA and NSSGA collectively represent a significant portion of the underground metal/nonmetal mines in the United States.

The technical feasibility of mines to achieve the elemental carbon (EC) limits - both interim and final - has not been demonstrated by MSHA. It has not been demonstrated by the latest scientific research and evidence, such as the extensive field tests conducted by a partnership of NIOSH, industry and labor, in which MSHA participated. Neither has it been demonstrated by extensive studies conducted at several mines and reported in these comments.

As demonstrated in these comments, there is no transparent, reproducible scientific analysis demonstrating feasibility that has been produced by MSHA. In contrast, the recent NIOSH partnership research at Stillwater Mine resulted in the conclusion that an enforcement extension was needed for the 400 TC / 308 EC micrograms per cubic meter standard since it was not feasible to comply with the standard at this time and perhaps for the foreseeable future. This mine conducted the most extensive installations and tests of DPM controls in the history of diesel research and still can not feasibly comply with the rule, directly contradicting MSHA's regulatory and theoretical conclusion.

These and other results of the latest scientific and engineering research discussed below have provided further proof that it is not technically feasible to comply with the 400 TC / 308 EC standard at those significant segments of the underground mining industry with current TC/EC levels above the standard. These non compliance mines have been estimated by MSHA's "compliance assistance sampling" to be 30 percent of the mines, but as set forth below, we believe this is an underestimate.

MSHA primarily bases its assumption that compliance with the interim and final DPM rule exposure limits is technically feasible on conclusions reached during its "31-mine study." The findings and conclusions arising from that study were published in the MSHA report and referenced in the preamble to this rule. The primary method for compliance assumed by the agency in its report was the use of diesel particulate filters (DPFs). The ability of the mines to achieve compliance was predicted by the use of MSHA's Estimator. MSHA's continued reliance on the Estimator and DPM filters, in this rulemaking, to conclude that the Interim and Final DPM limits are technically and economically feasible was proven wrong, again, during several mines' own trials and the NIOSH/Industry/Labor partnership field tests of DPM controls, as described below.

Fitting DPFs to a relatively the few pieces of diesel-powered equipment that are suited to their use may reduce DPM exposure levels, but will not bring mines into compliance. Based on the experiences of several mines with filters, the costs of applying DPF technology will be several orders of magnitude greater than projected by MSHA.

Major ventilation upgrades needed to increase intake airflow to dilute DPM to acceptable limits are expensive, and may not be feasible at many mines.

Alternative technologies, such as the use of biodiesel fuel, will add significant operating costs, and may not be applicable to the equipment or cause operational problems.

When MSHA compliance cost estimates in the PREA, FRIA and in the 31-mine study report are compared with the costs developed by mines after extensive research, the actual compliance cost for the industry is likely at least an order of magnitude higher than the $24.19 million annual cost that MSHA has projected.

Conclusion: Based on the analysis presented herein, a significant percentage of operations can not meet the 400 micrograms TC per cubic meter interim standard and none can meet the 160 micrograms TC per cubic meter final standard.

1.0 Introduction

MACTEC Engineering & Consulting, Inc. (MACTEC) was retained by the MARG Diesel Coalition (MARG), in conjunction with the National Mining Association (NMA) and the National Stone Sand and Gravel Association (NSSGA) to undertake an assessment of the technical and economic feasibility of the Diesel Particulate Matter (DPM) Exposure Rule for Underground Metal and Nonmetal Miners.

MARG, NMA and NSSGA collectively represent a significant portion of the underground metal/nonmetal mines in the United States.

These comments address the technical and economic feasibility of compliance with the MSHA diesel particulate matter (DPM) "Interim" exposure limit of 308 micrograms of elemental carbon (EC) (formerly 400 micrograms of total carbon, TC) per cubic meter as set forth in the proposed rule, and with the "Final" exposure limit of 160 micrograms of total carbon (TC) (which will be adjusted to an equivalent EC value) and comes into effect on January 20, 2006.

2.0 Technical Feasibility

The technical feasibility of mines to achieve the EC limits - both interim and final - has not been demonstrated by MSHA, nor by the latest scientific research and evidence, such as the extensive field tests conducted by a partnership of NIOSH, industry and labor, in which MSHA participated, nor by extensive studies conducted at several mines and reported in these comments.

As demonstrated in these comments, there is no transparent, reproducible scientific analysis demonstrating feasibility that has been produced by MSHA. In contrast, the recent NISOH partnership research at Stillwater Mine resulted in the conclusion that an enforcement extension was needed for the 400 TC / 308 EC micrograms per cubic meter standard since it was not feasible to comply with the standard at this time and perhaps for the foreseeable future. This mine conducted the most extensive installations and tests of DPM controls in the history of diesel research and still can not feasibly comply with the rule, directly contradicting MSHA's regulatory and theoretical conclusion.

These and other results of the latest scientific and engineering research discussed below have provided further proof that it is not technically feasible to comply with the 400 TC / 308 EC standard at those significant segments of the underground mining industry with current TC/EC levels above the standard. These non compliance mines have been estimated, by the sampling carried out during MSHA's "compliance assistance visits" (CAVs), to be 30 percent of the mines, but as set forth below, we believe this is an underestimate.

The baseline DPM data that MSHA obtained from its CAVs at the 171 metal/nonmetal mines is listed in Appendix A. (The data was provided to this author in a fashion that allowed individual mine data to be separated and identified by an arbitrarily assigned Mine No.) This data has been used extensively by MSHA in the proposed rule to support its proposal and conclusions.

However, an examination of this 171-mine data and reports from mine operators suggest that many mines were sampled in a manner that rendered the results exceedingly low and not representative of their operating conditions. For example, the MSHA compliance/feasibility estimate is based on: a report of negligible DPM at a lead-zinc mine with only a single sample of a mechanic at 9 TC, indicating possible "care-and-maintenance" duties, as opposed to full production (see Mine No. "161"); a crushed and broken limestone mine supposedly in compliance based on three samples, two reported at zero and one at 94 TC (see Mine No. "97") regardless of the use of large equipment with much higher expected TC levels; and two other crushed and broken limestone mines with large equipment where one sample on front end loader operators, who were the only individuals sampled at both mines, reported exposure levels of 11 and 16 TC (see Mines No. "57" & "156").

In our experience of those mines who have conducted their own rigorous sampling programs to measure their miners' exposure to DPM, the MSHA reported levels are underestimates of the levels that will be recorded during routine enforcement sampling when MSHA directives require that the individual with the highest potential exposure be sampled. Even the trona mines, with the lowest DPM values of all mines resulting from their inherently high ventilation rates, have had excursions above the 400 TC / 308 EC interim DPM exposure limit.

Thus the rosy picture of theoretical compliance with the interim DPM exposure limit is completely false, masked as it is behind averages of multiple samples and sampling of low exposure personnel. As mines will be cited on the basis of a single sample taken during MSHA routine enforcement sampling, a single excursion taken during peak productions operations in a routine faceline location must be the judge of the mining industry's ability to come into compliance with the interim DPM exposure level.

The latest scientific research and evidence demonstrates that it will not be feasible for a significant segment of the industry to comply with the Interim standard and that there is no feasible technology available, predictable, or on the horizon for all of the underground mines to comply with the 2006 DPM exposure level.

2.1 Baseline DPM Sampling Data

This Baseline DPM sampling data from the 171 mine CAVs is summarized in the tables on the next two pages:

171-Mine Baseline DPM Data -- Mines that Exceed the Interim 400 TC PEL				
Commodities	No. of Mines Sampled	Mines with "Interim PEL Violations" *		Maximum "Violation" (micro-g/m3)
		No.	Percent	
Clay, Ceramic & Refractory Minerals Mining, N.E.C.	1	1	100%	419
Construction Sand & Gravel Mining, N.E.C.	1	-	0%	n/a
Copper Ore Mining, N.E.C.	1	1	100%	474
Crushed & Broken Limestone Mining, N.E.C.	85	29	34%	1,109
Crushed & Broken Marble Mining	4	-	0%	n/a
Crushed & Broken Sandstone Mining	1	-	0%	n/a
Crushed & Broken Stone Mining, N.E.C.	5	1	20%	431
Dimension Limestone Mining	4	-	0%	n/a
Dimension Marble Mining	3	-	0%	n/a
Gemstones Mining, N.E.C.	1	-	0%	n/a
Gold Ore Mining, N.E.C.	17	5	29%	1,018
Gypsum Mining	2	-	0%	n/a
Hydraulic Cement	1	-	0%	n/a
Lead-Zinc Ore Mining, N.E.C.	10	4	40%	2,014
Lime, N.E.C.	4	-	0%	n/a
Limestone	2	-	0%	n/a
Miscellaneous Metal Ore Mining, N.E.C.	1	-	0%	n/a
Molybdenum Ore Mining	2	-	0%	n/a
Platinum Group Ore Mining	2	2	100%	1,459
Potash Mining	3	1	33%	502
Salt Mining	14	5	36%	824
Silver Ore Mining, N.E.C.	3	2	67%	622
Talc Mining	1	-	0%	n/a
Trona Mining	3	-	0%	n/a
Average of All Samples	171	51	30%	1,109

Mine Type	No. of Mines Sampled	Mines with "Interim PEL Violations" *		Maximum "Violation" (micro-g/m3)
		No.	Percent	
Stone	109	30	28%	1,109
Metal/Nonmetal (excluding trona)	23	7	30%	824
Metal	36	14	39%	2,014
Trona	3	-	0%	n/a
Average of All Samples	171	51	30%	1,109

171-Mine Baseline DPM Data -- Mines that Exceed the Final 160 TC PEL			
Commodities	No. of Mines Sampled	Mines with "Final PEL Violations" *	
		No.	Percent
Clay, Ceramic & Refractory Minerals Mining, N.E.C.	1	1	100%
Construction Sand & Gravel Mining, N.E.C.	1	1	100%
Copper Ore Mining, N.E.C.	1	1	100%
Crushed & Broken Limestone Mining, N.E.C.	85	55	65%
Crushed & Broken Marble Mining	4	2	50%
Crushed & Broken Sandstone Mining	1	-	0%
Crushed & Broken Stone Mining, N.E.C.	5	5	100%
Dimension Limestone Mining	4	2	50%
Dimension Marble Mining	3	2	67%
Gemstones Mining, N.E.C.	1	1	100%
Gold Ore Mining, N.E.C.	17	13	76%
Gypsum Mining	2	1	50%
Hydraulic Cement	1	-	0%
Lead-Zinc Ore Mining, N.E.C.	10	9	90%
Lime, N.E.C.	4	3	75%
Limestone	2	-	0%
Miscellaneous Metal Ore Mining, N.E.C.	1	1	100%
Molybdenum Ore Mining	2	1	50%
Platinum Group Ore Mining	2	2	100%
Potash Mining	3	3	100%
Salt Mining	14	10	71%
Silver Ore Mining, N.E.C.	3	3	100%
Talc Mining	1	1	100%
Trona Mining	3	2	67%
Average Of All Samples	171	119	70%

Mine Type	No. of Mines Sampled	Mines with "Final PEL Violations" *	
		No.	Percent
Stone	109	70	64%
Metal/Nonmetal (excluding trona)	23	17	74%
Metal	36	30	83%
Trona	3	2	67%
Average Of All Samples	171	119	70%

The two primary conclusions that MSHA has from this data are

- that nearly one third of the underground metal/nonmetal mining industry is unable to comply with the interim DPM exposure limit, and
- that almost one third of all mines are already in compliance with the final DPM exposure limit.

We believe that these conclusions substantially underestimate the ability of the industry to comply with the interim and final DPM exposure limits. The sampling data is comprised of averages, unlike the single sample that is required for compliance determinations. The sampling exercise was deficient in so far as too few samples were obtained for any confidence to be derived from the analysis. In addition, sampling occurred at less than normal production conditions at many mines. We believe that significantly more mines than these will, in fact, be in violation of the interim DPM exposure limit when compliance sampling starts in earnest.

2.2 The MSHA "Estimator"

MSHA primarily bases its assumption that compliance with the interim and final DPM rule exposure limits is technically feasible on conclusions reached during its "31-mine study." The findings and conclusions arising from that study were published in the MSHA report and referenced in the preamble to this rule. The primary method for compliance assumed by the agency in its report was the use of diesel particulate filters (DPFs). The ability of the mines to achieve compliance was predicted by the use of MSHA's Estimator. The record of this rulemaking contains a May 2002 report by Harding ESE, Inc. (now known as MACTEC) describing the deficiencies of MSHA's report and reaching an opposite conclusion. This report, attached as Appendix B, contained the following major conclusions:

- The DPM Rule is not feasible and the MSHA feasibility conclusions are based upon incorrect assumptions and inaccurate and incomplete data.
- MSHA's technical and economic feasibility analysis for the new rule is based entirely on using its Estimator to predict exposure levels in the 31 mines of the DPM Study, and then to assume that this analysis is applicable to the U.S. underground metal/nonmetal mining industry, a total of about 200 mines. Yet, the 31 mines are not

representative of the underground industry and MSHA's feasibility conclusion based on this assumption is incorrect.

- The math which forms the basis for the Estimator's calculations cannot be challenged - total exhaust emissions from diesel equipment (in grams/hr) when diluted with mine ventilation air flows (in cubic feet per minute) yield an estimated DPM concentration (in micro-gram per cubic meter), if the emissions are perfectly mixed with the air flow.

  However, the two input parameters - total exhaust emissions, both raw and reduced by particulate control devices, and mine ventilation air flows - are subject to interpretation and assumptions and MSHA's primary assumptions: perfect air mixing and commercial availability of the feasible and effective filtration devices do not exist in reality.

- DPM sample results in isolated sections of the 31 mines in the study are assumed by MSHA to be representative of on-going DPM exposure levels in those mines, despite the fact that results varied widely - indicative of imperfect mixing. Thus, using the Estimator and assuming complete and thorough mixing of the emissions with ventilation is a flaw in the feasibility analysis which renders it invalid as a scientific and engineering based method of analysis.

- Ventilation flows are assumed by MSHA to apply throughout the section where the sample was taken, and effective ventilation for dilution of the exhaust particulate is assumed to exist throughout the mine. This MSHA assumption is negated by the vastly differing sampling results from section to section, and even from individual to individual in the same mine.

- MSHA's feasibility analysis also is rendered invalid by the additional assumption that only equipment operating during the time of the sampling are assumed to need controls, without regard to the total fleet of diesel-powered equipment needed for production.

- Most importantly, emission control devices - exhaust filters or particulate traps - are assumed by MSHA's feasibility analysis to be at least 80 percent effective, but even NIOSH has said that there is no research demonstrating the effective use of these filters in underground environments, especially for larger, plus 250 hp, engines. Again, the assumption upon which MSHA's feasibility determination is based is simply invalid, rendering the conclusion invalid. A further problem with the "put a filter on it" solution espoused by MSHA is that NO_2 levels have been increased on engines fitted with filters, creating an unhealthful working environment.

- MSHA's feasibility analysis assumes that none of the 31 mines will need any major changes to its ventilation system. Only six of the 31 mines are allocated any funding by MSHA's analysis for auxiliary fans and ducting, for a total capital cost of $234,400. In contrast, one mine alone estimates at least $4.4 million in ventilation changes to achieve compliance. MSHA relies on this erroneous limited ventilation system change assumption despite an MSHA and NIOSH conclusion that mine ventilation systems throughout the industry - especially in underground stone mines – need substantial upgrades.
- MSHA's feasibility conclusion relying on no major ventilation additions in the industry is contradicted by the three trona mines in the study which recorded compliance with the DPM limits using ventilation quantities averaging 1.29 million cubic feet per minute (cfm) (needed for methane gas control). These primary airflows in the trona mines can be contrasted against the eleven stone mines in the study which were out of compliance with the DPM limits and averaged main airflows of only 99,000 cfm (with nine of the fourteen readings estimated by MSHA sampling personnel as essentially zero flow - See Table 1).

MSHA's continued reliance on the Estimator and DPM filters, in this rulemaking, to conclude that the Interim and Final DPM limits are technically and economically feasible was proven wrong, again, during several mines' own trials and the NIOSH/Industry/Labor partnership field tests of DPM controls, as described below.

Requests by this author for detailed information contained within the MSHA feasibility model were denied. No equipment inventories at the regulated mines were submitted at any stage in the rulemaking. Requests for ventilation plans and detailed ventilation quantities and system descriptions at the time of the 31-mine study produced only a refusal to release such information. An example of the deficiency of the data presented for the record, in what was supposed to be "... a Joint MSHA/Industry Study of DPM Levels in Underground Metal And Nonmetal Mines", was the very limited ventilation data that was submitted as part of the data spreadsheet collected in this supposedly "joint" effort. This is abstracted in Table 1 of Appendix B; an example of the serious shortcoming in the manner that the ventilation data was used in the analysis is the fact that nine of the fourteen readings in the eleven stone mines in the study were estimated by MSHA sampling personnel as essentially zero flow.

The withholding of such information violates the need for transparency and appears unjustified since it was collected for the public record. To our knowledge, no confidentiality claims were made by the any of the involved companies regarding the information, and/or the information could easily have been masked and still released to permit analysis.

With fewer than 200 mines impacted by this rulemaking, it is unfortunate that a full and open MSHA technology feasibility study was neither conducted not permitted to be conducted by others.

2.3 MSHA Inventory

Importantly, MSHA has not released its full database of equipment descriptions and ventilation plans and data for the mines impacted to permit complete descriptions of the errors of the Estimator.

For example, in response to a request for an equipment inventory of the mines impacted by the proposed rule, MSHA submitted the list in Appendix C; this contains no manufacturer information, no year of manufacturer, no model numbers, no DPM control information, and no other specifics that would have permitted more extensive analysis. The horsepower data in the list is limited to a split at 150 hp - greater than or less than 150 hp. This is inadequate for a meaningful analysis of control options.

Given MSHA's refusal to release data, the only method of apportioning more engine data to the limited MSHA-supplied inventory is to pro-rate the engines in the same ratio as found in the "31-mine study." This is included in Appendix C, as a table of "filters, fittings and engines."

Those engines in the "250-350 hp" and ">350 hp" ranges are considered unsuitable for DPFs with present technology. This general conclusion of unsuitability for DPF usage for these large engines comes from use of DPFs in real mine situations. These are summarized as follows:

- The larger engines require physically bigger DPFs, which are frequently unsuited for underground applications. The constraints on opening size prevents major additions to already stripped down vehicle profiles.
- The larger engines tend to be used predominantly on haulage units, such as big trucks and loaders where duty cycles are unsuited to DPF applications, especially in stone and salt mine applications. Research has focused on resolving DPF issues for engines in the 150 - 250 hp range, and for those pieces of diesel-powered equipment that have heavy duty cycles and high exhaust temperatures.

These large units make up a combined 59 percent of the equipment in MSHA's inventory of ">150 hp" units listed for "filters, fittings and engines." The equipment inventories can be assumed to be representative in their split of engine sizes when compared to those in use throughout the entire underground metal/nonmetal mining industry. The MSHA-supplied inventory for the industry lists a total of 1,230 units ">150 hp" for 196 mines. This should be reduced to equate to the presently-operating 171 mines, or 1,073 units. A total of 633 units, representing 59 percent of 1,073 of the ">150 hp" engines, can be assumed from this and field testing data, as not capable of being fitted with DPFs using available technology.

Thus fully 41 percent of the total 1,529 diesel-powered production units of all engine sizes could not be fitted with the technology that has formed the backbone of MSHA's compliance strategy.

2.4 Specific Mines' Experiences with Diesel Particulate Filters (DPFs)

2.4.1 Stillwater Mining Company - Nye Mine

There are 350 diesel-powered equipment units in operation at the Stillwater Nye Mine. The inventory of the Stillwater Mine diesel equipment and the Mine's ventilation plans are contained within MSHA's files and incorporated by reference in these comments.

The Stillwater tests and NIOSH field tests demonstrated that of the 350 diesel units, only 29 have duty cycles that probably will allow the use of passive filters. These include nineteen primary haulage trucks, eight locomotives and two large LHDs (Elphinstone R1500s). However, even for these units, it has been seen that the passive system will not work when multiple units are operating in close proximity and are installed with new traps. (a scenario that will take place frequently in many of the mine's work sites)

The tests and experience demonstrated that 321 diesel-powered units (76 smaller LHDs used by the production miners and 245 miscellaneous/service units) do not have high enough duty cycles and engine temperatures to use DPFs that regenerate passively.

The 29 units that may be fitted with DPFs are estimated to generate 35 percent of the mine's DPM emissions. The balance of the mine's fleet contribute the remaining 65 percent of the emissions, split as follows: 76 smaller LHDs 30 percent of the emissions, balance of the fleet 35 percent.

Those units that can be fitted with DPFs tend to be working in haulageways, where there is frequently a good flow of ventilation. The smaller LHDs that cannot be fitted with DPFs are used in production and development headings and in production stopes, where good ventilation is sometimes difficult to achieve.

Some types of passive filters have proven successful for some diesel-powered units at the mine, both in independent trials and in collaboration with NIOSH and MSHA technical staff. These include Englehart and DCL Mine X DPFs.

Several types of filters have been shown to be unacceptable for mine use. These include DCL Blue Sky (an active filter, requiring off-board regeneration), Donaldson (too big to be mountable on production units), Clean Air (requires a fuel borne catalyst), and ECS CT 28 Cat Trap (catalyzed wash coat on the filter produced high levels of NO_2).

Stillwater's experience and conditions demonstrated that "active filters" are impractical and not feasible because of: (1) the need for utilities, such as electrical power for ovens, compressed air to blow out the filters, and water to wash off the residue: (2) new oversize excavations needed for regeneration service areas that pose potential ground control problems; and (3) operational constraints, such slack time for regeneration and marshalling vehicles distributed throughout the mine. Our analysis was based on an active system that regenerates by plugging in to a regeneration station. The DPFs would not need to be removed for cleaning unless the regeneration process was unable to properly clean the filter element, to lower the back pressure.

Fuel borne catalysts are impractical because of the need to apply the catalyst to the entire fuel supply for the mine. Separate fuel types - one with and one without the catalyst - would be impractical logistically.

The generation of NO_2 is a major problem encountered by the mine in its filter tests. Catalyzed DPFs allow for lower filter regeneration temperatures, making passive filters operable with lighter duty units. However, these have shown to elevate NO_2 levels to unsafe levels, well beyond the 5 ppm ceiling personal exposure level mandated by mine health standards. Substituting an alleged airborne contaminant - DPM - with a known contaminant - NO_2 - is unacceptable.

A passive DPF program for the 29 larger diesel-powered equipment is estimated to cost at least $250,000 for installation, with increased operating costs of some $75,000 for replacement traps per year. Down time and lost production represent additional costs but has not been calculated for installation and trap replacements.

If the mine installs DPFs on the 29 larger diesel-powered equipment, it will only remove a portion - say 80 percent - of the emissions generated by those units. The remaining 72 percent of the initial emissions (7 percent from the large units (being 20 percent of the 35 percent from these units) and 65 percent from the smaller LHDs and miscellaneous units) will continue to circulate through the mine. Those production areas where good ventilation can be difficult to achieve will still see elevated DPM levels, above the interim DPM exposure level.

The mine believed that an active system was the only technical method of further lowering DPM exposure levels and has estimated that is would cost almost $3 million. This factored on 175 traps at $8,300, plus 88 spare traps at $6,000, replaced at the rate of once every other year. An additional cost of $5,400 per cleaning station for two traps. However, this program was later considered to be impractical because of the elevated levels of CO and NO_2 in the mine that would be generated by the use of so many filters.

The mine believes that it will not be able to achieve the final DPM exposure level with any type of ventilation upgrade or exhaust control technology known at this time. It has already spent $5.8 million on ventilation upgrades linked directly to the DPM rule.

In contrast, the Estimator analysis in MSHA's "31-mine study" for Mine S (Stillwater Nye Mine) was run using one LHD and three trucks in a section with 26,000 cfm and an intake DPM concentration of 50 TC µg/m3. The analysis assumed that fitting 80 percent efficient DPFs would be all that was needed to get below the interim concentration limit of 400 TC µg/m3; and that only one truck would need to have a low-emission engine installed to get to the final concentration limit of 160 TC µg/m3. The conclusion in the economic estimates was that a total of 6 LHDs and 16 trucks would need filters to get to the interim concentration limit of 400 TC µg/m3; and that 5 trucks would need to have low-emission engines installed to get to the final concentration limit of 160 TC µg/m3. This would be done at a total capital cost of some $933,000, with increased operating costs of some $108,000 per year.

2.4.2 Newmont Gold Company - Carlin East and Deep Post Mines

Newmont has been experimenting with DPFs for several years in an attempt to reduce DPM exposure levels in its underground gold mines.

One of Newmont's mines has equipped diesel-powered units with passive filters requiring little operator intervention, where exhaust temperatures are high enough to allow regeneration, and active filters on some units with lower duty cycles and correspondingly lower exhaust temperatures Compliance with the 308 EC level was not projected by Newmont in the near future, even with extensive efforts.

Newmont faces constraints in its DPM reduction efforts due to the instructions of its equipment manufacturers. Caterpillar has stated that it will not honor the warranties on their engines when exhaust backpressures exceed 27 inches Hg. This is low when using filters, where backpressures run typically from 37 to 43 inches Hg. Manufacturers have provided dual filters to get more surface area but are reluctant to provide oversized filters because they lead to filter failures as the large filter elements vibrate loose and come apart. Newmont has installed dual filters on a trial bases but they have been subject to damage because of their size they extend outside the machine profile.

Newmont has had some success with passive filters which are wash coated with a platinum catalyst to reduce regeneration temperatures even though NO2 has been elevated in the exhaust gases after these DPFs. The ambient air NO2 levels where these Newmont units run are not seriously affected because the passive filters are typically used on trucks hauling ore up the ramp out of the mine - areas with significantly higher air flows than other areas of the mine. Newmont will have to monitor this application, however, to insure that NO_2 hazards are not encountered as they have been at other mines.

Newmont also has had limited success with active filters, treated with base metal catalysts, on some smaller engines on LHDs and "jammers" in confined production areas. The filters were sized to allow for regeneration or change-out at set service intervals, to coincide with preventive maintenance schedules. These experiments will require further evaluation as Newmont's DPF control efforts continue.

Newmont's experienced several failures of the installed DPFs. For example, one vertically mounted unit failed when excess vibration shook the filter element to pieces. Another failure occurred when a turbocharger failed and blew oil into the DPF. The first failure was resolved by adding shock absorbers to the mounts; the second did not reoccur after the filter was replaced.

One major issue at Newmont resulting from DPF use is their high cost. Newmont has estimated that the purchase and installation of DPFs, including downtime on production vehicles, will be $1.9 million for its two mines – Deep Post and Carlin East.

The Estimator analysis in MSHA's "31-mine study" for Mine X (Newmont Carlin East Mine) was run using three LHDs (1 Jammer and 2 Muckers), seven trucks and a roof bolter in a section with 14,000 cfm and an intake DPM concentration of 50 TC μg/m3. The analysis assumed that fitting 80 percent efficient DPFs would be all that was needed to get below the interim concentration limit of 400 TC μg/m3; and that the ventilation into the section would have to be doubled to 28,000 cfm to get to the final concentration limit of 160 TC μg/m3. The conclusion in the economic estimates was that a total of 6 LHDs and 14 trucks would need filters to get to the interim concentration limit of 400 TC μg/m3; and that two roof bolters would need filters to get to the final concentration limit of 160 TC μg/m3; the ventilation increase in the section would be achieved with three new auxiliary fans and 600 ft of ventilation tubing installed. This would be done at a total capital cost of some $488,000, with increased operating costs of some $120,000 per year.

The primarily flaw in the use of the Estimator is revealed in this simplistic analysis. It is simply not possible to double intake airflows by the use of auxiliary ventilation systems. The main ventilation system needs to be upgraded to deliver fresh, intake air to the working faces. The capital cost for a new ventilation raise to increase airflow through the mine is estimated by the mine to be $1.1 million, with another $414,000 per year in operating costs. This is in contrast with the $39,600 capital cost and $40,819 per year operating cost for the auxiliary ventilation in the 31-mine study report.

Even with the substantial expenditures in DPFs and ventilation system upgrades projected above, Newmont almost certainly will not be able to consistently achieve the 400 micrograms TC per cubic meter interim exposure limit, and has gone on record stating that there is no "... feasible method of compliance with the 160 [micrograms TC per cubic meter final exposure limit] standard."

2.4.3 Kennecott Minerals Company - Greens Creek Mine

Kennecott's Green Creek Mine uses trucks to haul ore out of the mine up its ramp system. The primary haulage units are six Toro 40D 40-ton haul trucks, fitted with Detroit Series 60 engines, rated at 475 hp.

These were the primary focus for DPM exposure level reductions. The mine worked with Englehart to come up with workable DPFs to reduce exhaust emissions from the units. After initial problems, mainly caused by incorrect installation and sizing of the filters, the mine has successfully equipped its fleet of six Toro trucks with DPFs.

The DPFs have a platinum wash coat, to allow the filters to regenerate passively. There have been 1 – 2 ppm increases in NO_2 levels, but these have been manageable. One problem with the Englehart filters is that they vibrate loose in the binding "can" holding the four quadrants of the filter elements together; this can lead to the ceramic filter elements progressively degenerating, allowing the exhaust to bypass the filter entirely.

Kennecott experimented with two identical Toro 1250 LHDs, fitted with Detroit Series 60 engines rated at 350 hp, by fitting them with passive DPFs. The one that was consistently worked harder had exhaust temperatures in the 390 degree C range, while the other lower-duty unit had exhaust temperatures of only 340 – 350 degrees C. The DPF on the first one regenerated without any problems, but the other one did not. This demonstrates the extreme sensitivity of duty cycle and exhaust temperature to the ability to use DPFs. Fuel doped with a catalyst to reduce regeneration temperature may have been an option, but was rejected because of substantial logistical fueling and operational problems.

A similar problem with the application of DPFs, despite the best engineering available, was experienced by Kennecott with a new Wagner 436 haul truck, fitted with an OEM aftertreatment DPF package. This was designed by Wagner, Detroit Diesel, and Englehart engineers, but did not work in practice. The failure resulted from low exhaust temperatures when hauling waste rock down the ramp and on relatively flat hauls. Had the unit been used for ore haulage on uphill routes, it might have achieved the high exhaust temperatures for the designed passive regeneration. However, this application-specific use of equipment fitted with DPFs would add another level of equipment scheduling and allocation problems to the compliance efforts and to the burdens of and duties of the mine supervisors.

Greens Creek has successfully tried a DCL Blue Sky "active" filter on an Elphinstone R1300 3-1/2 yd LHD, fitted with a Cat engine. This unit is used as a clean up loader with relatively light duties, so would not be a candidate for a passive filter as the exhaust temperatures do not get high enough to regenerate the filter element. It has sufficient down time during the day to allow it to be parked for 3 hrs or so to clean out the filter.

However, active filters would not be an option with high-use production equipment, which is frequently operated with a "hot change," i.e. the on-coming operator takes over from the operator going off shift on the unit in the faceline. This type of equipment utilization does not permit the collection of equipment for regeneration, nor the inherent down time involved.

The Kennecott mine is experiencing DPM exposure levels of just below 400 micrograms TC per cubic meter, with occasional excursions above the interim exposure limit that we believe demonstrate that compliance with the interim standard is still not feasible. Kennecott does not consider the final DPM exposure limit feasible, given its series ventilation system, and with only limited increases in air flow capable of being achieved.

The Estimator analysis in MSHA's "31-mine study" for Mine Y (Kennecott Greens Creek Mine) was run using three LHDs (1 Jammer and 2 Loaders) and two trucks (one on production and one on backfill) in a section with 3,350 cfm and an intake DPM concentration of 50 TC µg/m3. The analysis assumed that fitting 80 percent efficient DPFs would be all that was needed to get below the interim concentration limit of 400 TC µg/m3; and that the ventilation into the section would be increased to 6,900 cfm to get to the final concentration limit of 160 TC μg/m3. The conclusion in the economic estimates was that a total of 6 LHDs and 14 trucks would need filters to get to the interim concentration limit of 400 TC μg/m3; and that the ventilation increase in the section would be achieved with three new auxiliary fans and 600 ft of ventilation tubing installed. This would be done at a total capital cost of some $472,000, with increased operating costs of some $97,000 per year.

Again the primarily flaw in the use of the Estimator is revealed in this simplistic assumption of improved section airflow rates. It is simply not possible to triple intake airflows by the use of auxiliary ventilation systems. The main ventilation system would need to be substantially upgraded to deliver fresh, intake air to the working faces.

2.4.4 Cargill Salt Company - Avery Island Mine

Cargill Salt's Avery Island Mine operates a fleet of large Cat 775 60-ton haul trucks and Cat 992 front end loaders.

The mine has fitted a DCL Mine X DPF with two 15 x 15 filters in parallel (one on each bank of the V-12 engine) on a 7-year old Cat 992G loader, with a Cat 3412 engine, rated at 650 hp.

The work was done in close collaboration with the local Caterpillar dealer - Louisiana Machinery of Lafayette. The Cat and mine mechanics undertook major modifications to the superstructure of the unit to fit the massive filter assembly. The exhaust system was fitted with all the necessary temperature and pressure probes. The total cost of the filter was about $24,000, made up as follows: $17,210 for filters, $1,800 for backpressure monitors, $1,750 for heat blankets, and $3,200 for labor. [I hope to have photographs by Monday.]

The DPF has a platinum catalyst wash coat, to enable it to regenerate passively. There are no reported problems with elevated NO_2 levels. Visible emissions have been reduced.

Despite three months of on-going work with the Cat dealer, the filter has caused this valuable production unit to lose almost all of its power, to such an extent that it is essentially available only as a clean-up or utility loader. Specifically, a typical one-minute cycle to load and dump a bucket of salt has extended to more than three minutes. The loader also no longer has sufficient power to negotiate a 12-percent slope in the mine.

Based on this experience, Cargill Salt has decided that DPFs are not a feasible option for DPM compliance at the Avery Island Mine and we agree.

Cargill Salt has started a program of replacing older equipment with new units, fitted with clean-burning engines, as their primary method of reducing DPM exposure levels. The mine anticipates further reductions in DPM exposure levels by using biodiesel. Trials with 20 percent biodiesel fuel in test-bed trials have shown some promise.

DPM exposure levels in the mine are presently averaging 220 - 240 micrograms TC per cubic meter, with some faceline areas experiencing levels over 400. Based on the mine's experience, we do not believe that compliance with the interim standard is feasible at this time and that compliance with the final standard is not feasible in the foreseeable future.

2.5 Stone Mines

Stone mines represent the largest sector of the underground metal/nonmetal mining industry. There are 109 stone mines in the total 171 mines that MSHA undertook baseline sampling for DPM exposure levels.

Stone mines typically use large quarry-style mobile haulage equipment, with proportionately large diesel engines.

Few stone mines use trucks to haul up ramps. Ramp haulage is almost always by conveyor, following the mine's initial development. Most stone mines use trucks for haulage on essentially flat hauls, either within the mine to an in-mine crusher, or out of portals in the former quarry highwall to existing surface crushing and screening plants. Thus the duty cycles on these units are likely to be relatively low, and unsuitable for DPFs with passive regeneration. The large size of the engines argues against the use of active filters because of the difficulties of handling oven-regenerated filters.

Duty cycles of the large FELs used to load the stone mine trucks are unlikely to achieve high temperature duty cycles, as their work is intermittent, with bursts of activity, followed by idle time. Thus they, too, are unlikely to be suited for passive DPFs, and active DPFs are also unlikely to be feasible.

All those stone mines examined as part of the 31-mine study and for which equipment lists were made available use large haul trucks and loaders.

<u>31-Mine Study - DPFs needed on production haulage equipment to meet 400 limit:</u>

Mine C – 4 x 460 hp haul trucks and 2 x 325 hp FELs
Mine F – 3 x 350 hp haul trucks and 3 x 220 FELs
Mine H – 7 x 450 hp haul trucks and 4 x 375 FELs
Mine I – 9 x 600 hp haul trucks and 8 x 520 hp FELs
Mine J – 3 x 485 hp haul trucks
Mine L – 4 x 485 hp haul trucks and 3 x 470 FELs
Mine N – 3 x 425 hp FELs
Mine O – 3 x 450 hp and 2 x 350 hp haul trucks
Mine W – 2 x 525 hp haul trucks

This represents an average of 5 large haul trucks and 2-1/2 large FELs per mine.

A review of the diesel equipment inventories at NSSGA member stone mines reflects that all mines have similar haulage fleets. These diesel-powered units would be candidates for DPFs as part of the compliance strategy espoused by MSHA in the PREA. Thus there would be approximately 545 haul trucks and 273 FELs at the 109 stone mines that MSHA would have stone mines install filters on. Yet there is no documented evidence presented by the agency to demonstrate that practical mine-worthy DPFs are available for engines of this size and for the duty cycles as seen by these units. Evidence from unsuccessful attempts at Cargill Salt's Avery

Island Mine with a caterpillar 992G FEL leads to the conclusion that these mines will not be able to use the present technology DPFs to filter out the exhaust emissions from their production units.

DPM exposure levels in the stone industry have declined since the initial proposed DPM rule in 1998. This is because the stone industry has taken an active role in DPM exposure reduction as a part of their ongoing commitment to the health and safety of their workers. Techniques that have been widely accepted in the stone industry to reduce diesel exhaust emissions include:

- improving mine ventilation
  - new and bigger main fans
  - more strategically placed auxiliary fans
  - better ventilation system controls with stoppings and doors
  - new ventilation raises
- better engine maintenance
- replacement equipment, fitted with clean-burning engines
- replacement clean-burning engines, in existing equipment
- the use of biodiesel and other alternative fuels and fuel systems

Emission rates are lower but are still not in compliance with the interim DPM exposure limit. 30 of the 109 stone mines sampled as part of the 171-mine CAV baseline sampling exercise were in violation of the interim DPM exposure limit based on the CAV sampling, with significantly more suspected by this author as out of compliance as explained above.

Significant further reductions are likely to be difficult as most mines have exhausted the relatively easy methods. Consistently remaining below the final DPM exposure limit will be prohibitively expensive, requiring reductions in diesel-powered equipment applications and subsequent losses in productivity.

2.5.1 Carmeuse Lime, Maysville Mine

The use of biodiesel fuel has been touted as one of the compliance strategies to reduce DPM exposure. Work done by Carmeuse Lime at its Maysville and Black River Mines has shown promising results. This was reported at the Public Hearing for this NPRM at Pittsburgh, Pennsylvania, by George Love. Mr. Love described limited DPM reductions available when using biodiesel of with 20 and 50 percent mixes. He also described the problems with fuel filters and power loss with newer engines, and the likely increased cost of biodiesel in the future.

The price of biodiesel is sensitive to demand. There is only a certain volume of biological oils, such a fats and greases, available in any one area, and many areas where it is not available. The likelihood of significant price increase in the cost of biodiesel fuel has not been factored into MSHA's cost analysis. As the demand has been elevated in northern Kentucky during the trials at the two limestone mines, the price has gone up to $1.67 per gallon, compared to $0.89 per gallon for low sulfur fuel. This $0.78 per gallon difference represents a significant total cost when applied against the estimated usage of diesel fuel for the underground mining industry. Fuel consumption estimates presented in this author's response to the PREA in 1999 showed that the 96 U.S. underground mines that responded to a request for information used about 17.9 million gallons of diesel fuel per year. This can be extrapolated to a total of 31.9 million gallons per year for the presently-operating 171 metal/nonmetal mines. Thus the incremental cost of using biodiesel could be as high as $24.9 million per year, if all mines switched away from standard low sulfur fuel. It is highly unlikely that the biodiesel supply could match this demand, further escalating prices.

While it is not the intention of this analysis to suggest that the incremental $24.9 million per year is a realistic cost projection, it is an illustration of the significant costs ignored in MSHA's cost projections. If biodiesel is to be recommended as a feasible method of reducing DPM, then its cost should be factored into the cost of compliance. Moreover, the equipment that is proposed for use with biodiesel must be examined to determine its acceptability by the manufacturer. As Mr. Love testified, certain manufacturers have prohibited the use of certain biodiesel fuels and others have caused operational problems.

3.0 Economic Feasibility

The economic feasibility of compliance with the DPM rule is dependent on the costs of compliance with the MSHA DPM exposure limits, assuming feasible engineering controls, and the economic viability of the various industry groups impacted by the rule. The less than 200 underground mines impacted by the standard are composed of 24 different commodities, each of which must be examined from the unique perspective of the market for its products, its existing margins, national and foreign competition, and product commodity market prices.

The underground mines in Missouri that produce lead, or the underground mines in Montana that produce platinum, or the underground mines in Nevada that produce gold, are each economically viable only when viewed in light of the international market price for their commodities, not their gross sales as used by MSHA to determine feasibility. Gross sales is a misleading indicator of economic feasibility as demonstrated by the multiple Arizona copper mines which have now been closed. Their massive gross sales produced massive losses, because of low metal prices caused by foreign competition. These overseas operations are at huge price advantages against domestic producers, primarily because of low wages in their labor markets and significantly lower regulatory compliance costs.

Underground stone mines do face international competition, but are fighting for market share dominated by surface quarries and sand and gravel pits. If stone prices from underground mines are driven up by higher costs of regulatory compliance, then stone from more distant surface resources become viable for local markets, threatening the viability of the underground mines.

In the "31-mine study" MSHA used unit prices for commodities that were significantly in error in at least one instance. For example, rock salt for highway de-icing (the primary market for the three rock salt mines included in the study) sells for about $20 to $25 per ton. Yet the estimates for the revenues and likely annual production levels of the three salt mines seems to indicate that a price of about $50 to $70 per ton was used in the analysis. It is highly likely that the USGS data used for these cost estimates included evaporative salt production and sales estimates.

3.1 Compliance Cost Conclusions

Unlike the theoretical cost estimates developed by MSHA using the flawed Estimator model, the mines listed above have actually "been there and done that." They provide a dose of reality into the economic feasibility question.

Fitting DPFs to a relatively the few pieces of diesel-powered equipment that are suited to their use may reduce DPM exposure levels, but will not bring mines into compliance. Based on the experiences of the mines above with filters, the costs of applying DPF technology will be several orders of magnitude greater than projected by MSHA.

Major ventilation upgrades needed to increase intake airflow for to dilute DPM to acceptable limits are expensive, and may not be feasible at many mines.

Alternative technologies, such as the use of biodiesel fuel, will add significant operating costs, and may not be applicable to the equipment or cause operational problems.

In the response to the 31-mine study (Appendix B), this author abstracted the annual operating costs and annualized capital cost estimates to yield the following:

MSHA Total annual operating and annualized capital costs to achieve:

• interim concentration limit	$2.09 million or	$67,500 per mine
• final concentration limit	$1.44 million or	$46,600 per mine
• both concentration limits	$3.53 million or	$114,100 per mine

If these MSHA costs could be extrapolated to the 196 underground mines operating in the U.S., this would equate to:

Total extrapolated annual operating and annualized capital costs to achieve (compared to the Final Rule FREA):

• interim concentration limit	$13.23 million	($17.58 million)
• final concentration limit	$9.13 million	($6.61 million)
• both concentration limits	$22.36 million	($24.19 million)

Specifically, the annual cost for compliance for Stillwater in the 31-mine study report was estimated to be:

- interim concentration limit $280,948
- final concentration limit $65,850
- both concentration limits $346,798

Stillwater prepared their its own estimate for compliance costs at the Nye Mine. These include costs to date to allow for partial compliance with the interim concentration limit at about $7.49 million, and a further $103.64 million for attempting to comply with the final concentration limit, which remains unfeasible. The total attempted compliance cost for both concentration limits is estimated to be $111.13 million, although compliance with the final limit is considered unfeasible. The ventilation upgrades alone at the Nye Mine have cost $5.86 million. MSHA projected zero increased costs for ventilation for the Stillwater mine.

Even if these total capital costs are amortized over five years ($22.23 million per year), they are almost 64 times higher than the costs projected by MSHA in its 31-mine study report.

If this specific differential between industry's and MSHA's cost projections hold fast for the industry as a whole, then the total annual cost of attempted compliance would be $1.55 billion.

In all probability this number overstates the real cost of attempted compliance for the industry. But it is just as close to reality as MSHA's projected costs. The agency has not provided adequate data for its estimates, which are clearly inconsistent with the facts, to be verified or reproduced. Regurgitating revised cost estimates - in the PREA, the FRIA and again in the 31-mine study - using the same flawed model leads to repetitive and similar errors. However, we can state that the cost for attempted compliance is undoubtedly going to exceed MSHA's optimistic estimate by significant amounts, and make compliance economically unfeasible for significant numbers of mines.

Maybe an annual compliance cost between $24.19 million and $1.55 billion is more realistic...

Conclusion: Based on this analysis, a significant percentage of operations can not meet the 400 micrograms TC per cubic meter interim standard and none can meet the 160 micrograms TC per cubic meter final standard.

APPENDIX A

DPM BASELINE SAMPLING DATA

874-DPM-Sample Universe Per MNM NPRM Discussion

Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
778	Backhoe operator	57	Dimension Limestone Mining	1	Stone	
782	Front-end loader operator	36	Dimension Limestone Mining	1	Stone	
825	Bobcat operator	48	Dimension Limestone Mining	1	Stone	3
367	Shovel operator	72	Crushed & Broken Limestone Mining, N.E.C.	2	Stone	
376	Truck driver	175	Crushed & Broken Limestone Mining, N.E.C.	2	Stone	
634	Drill operator, rotary	65	Crushed & Broken Limestone Mining, N.E.C.	2	Stone	
634	Drill operator, rotary	55	Crushed & Broken Limestone Mining, N.E.C.	2	Stone	5
782	Truck driver	255	Crushed & Broken Limestone Mining, N.E.C.	2	Stone	
376	Truck driver	346	Copper Ore Mining, N.E.C.	3	Metal	
376	Truck driver	284	Copper Ore Mining, N.E.C.	3	Metal	
782	Front-end loader operator	197	Copper Ore Mining, N.E.C.	3	Metal	
782	Front-end loader operator	40	Copper Ore Mining, N.E.C.	3	Metal	5
750	Truck driver	474	Copper Ore Mining, N.E.C.	3	Metal	
058	Miner, drift	132	Gold Ore Mining, N.E.C.	4	Metal	
058	Miner, drift	86	Gold Ore Mining, N.E.C.	4	Metal	3
782	Miner, drift	174	Gold Ore Mining, N.E.C.	4	Metal	
376	Truck driver	53	Construction Sand & Gravel Mining, N.E.C.	5	Stone	
376	Truck driver	40	Construction Sand & Gravel Mining, N.E.C.	5	Stone	
782	Front-end loader operator	26	Construction Sand & Gravel Mining, N.E.C.	5	Stone	
833	Drill helper	130	Construction Sand & Gravel Mining, N.E.C.	5	Stone	5
046	Blaster, powder gang	169	Construction Sand & Gravel Mining, N.E.C.	5	Stone	
029	Mucking machine operator	334	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	
029	Mucking machine operator	257	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	
029	Mucking machine operator	220	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	
029	Mucking machine operator	110	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	
375	Road grader operator	20	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	
376	Truck driver	212	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	
376	Truck driver	84	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	
376	Truck driver	82	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	9
634	Truck driver	265	Miscellaneous Metal Ore Mining, N.E.C.	6	Metal	
029	Mucking machine operator	263	Molybdenum Ore Mining	7	Metal	
046	Roof bolter, rock	252	Molybdenum Ore Mining	7	Metal	
053	Utility man	300	Molybdenum Ore Mining	7	Metal	
376	Truck driver	151	Molybdenum Ore Mining	7	Metal	
604	Mechanic	160	Molybdenum Ore Mining	7	Metal	
604	Mechanic	46	Molybdenum Ore Mining	7	Metal	
609	Nipper	61	Molybdenum Ore Mining	7	Metal	
619	Welder, etc.	216	Molybdenum Ore Mining	7	Metal	
622	Dump operator	42	Molybdenum Ore Mining	7	Metal	
706	Shotcrete/gunite man	227	Molybdenum Ore Mining	7	Metal	
708	Ventilation crew	37	Molybdenum Ore Mining	7	Metal	
750	Shuttle car operator (diesel)	95	Molybdenum Ore Mining	7	Metal	
807	Blaster, powder gang	174	Molybdenum Ore Mining	7	Metal	
934	Drill operator, jumbo percussion	156	Molybdenum Ore Mining	7	Metal	15
807	Miner, drift	331	Molybdenum Ore Mining	7	Metal	
378	Mobile crane operator	140	Dimension Marble Mining	8	Stone	
807	Front-end loader operator	306	Dimension Marble Mining	8	Stone	2
649	Supervisor, Co. official	1	Crushed & Broken Marble Mining	9	Stone	1
376	Truck driver	357	Crushed & Broken Marble Mining	10	Stone	
376	Truck driver	283	Crushed & Broken Marble Mining	10	Stone	
376	Truck driver	91	Crushed & Broken Marble Mining	10	Stone	
807	Blaster, powder gang	254	Crushed & Broken Marble Mining	10	Stone	5
029	Front-end loader operator	392	Crushed & Broken Marble Mining	10	Stone	
376	Truck driver	58	Crushed & Broken Marble Mining	11	Stone	
634	Drill operator, rotary	3	Crushed & Broken Marble Mining	11	Stone	
782	Front-end loader operator	78	Crushed & Broken Marble Mining	11	Stone	
807	Blaster, powder gang	6	Crushed & Broken Marble Mining	11	Stone	
847	Scaling (mechanical)	7	Crushed & Broken Marble Mining	11	Stone	5
376	Truck driver	81	Crushed & Broken Limestone Mining, N.E.C.	12	Stone	
734	Drill operator, rotary air	92	Crushed & Broken Limestone Mining, N.E.C.	12	Stone	
807	Blaster, powder gang	56	Crushed & Broken Limestone Mining, N.E.C.	12	Stone	
847	Scaling (mechanical)	129	Crushed & Broken Limestone Mining, N.E.C.	12	Stone	5
934	Front-end loader operator	316	Crushed & Broken Limestone Mining, N.E.C.	12	Stone	
376	Truck driver	77	Crushed & Broken Marble Mining	13	Stone	
634	Drill operator, rotary	4	Crushed & Broken Marble Mining	13	Stone	
782	Front-end loader operator	138	Crushed & Broken Marble Mining	13	Stone	
847	Scaling (mechanical)	174	Crushed & Broken Marble Mining	13	Stone	5
807	Blaster, powder gang	183	Crushed & Broken Marble Mining	13	Stone	
376	Truck driver	61	Crushed & Broken Limestone Mining, N.E.C.	14	Stone	
604	Mechanic	65	Crushed & Broken Limestone Mining, N.E.C.	14	Stone	
649	Supervisor, Co. official	26	Crushed & Broken Limestone Mining, N.E.C.	14	Stone	

874-DPM-Sample Universe Per MNM NPRM Discussion

Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
782	Front-end loader operator	27	Crushed & Broken Limestone Mining, N.E.C.	14	Stone	4
057	Miner, stope	403	Silver Ore Mining, N.E.C.	15	Metal	
057	Miner, stope	330	Silver Ore Mining, N.E.C.	15	Metal	
057	Miner, stope	304	Silver Ore Mining, N.E.C.	15	Metal	
057	Miner, stope	258	Silver Ore Mining, N.E.C.	15	Metal	
609	Nipper	328	Silver Ore Mining, N.E.C.	15	Metal	
616	Laborer, bullgang	377	Silver Ore Mining, N.E.C.	15	Metal	7
734	Miner, stope	622	Silver Ore Mining, N.E.C.	15	Metal	
029	Mucking machine operator	427	Silver Ore Mining, N.E.C.	16	Metal	
029	Mucking machine operator	122	Silver Ore Mining, N.E.C.	16	Metal	
029	Mucking machine operator	97	Silver Ore Mining, N.E.C.	16	Metal	
057	Miner, stope	496	Silver Ore Mining, N.E.C.	16	Metal	
057	Miner, stope	481	Silver Ore Mining, N.E.C.	16	Metal	
057	Miner, stope	434	Silver Ore Mining, N.E.C.	16	Metal	
057	Miner, stope	262	Silver Ore Mining, N.E.C.	16	Metal	
057	Miner, stope	168	Silver Ore Mining, N.E.C.	16	Metal	
057	Miner, stope	165	Silver Ore Mining, N.E.C.	16	Metal	
375	Road grader operator	269	Silver Ore Mining, N.E.C.	16	Metal	
376	Truck driver	572	Silver Ore Mining, N.E.C.	16	Metal	
376	Truck driver	510	Silver Ore Mining, N.E.C.	16	Metal	
376	Truck driver	476	Silver Ore Mining, N.E.C.	16	Metal	
376	Truck driver	297	Silver Ore Mining, N.E.C.	16	Metal	
604	Mechanic	126	Silver Ore Mining, N.E.C.	16	Metal	
618	Oiler, greaser	239	Silver Ore Mining, N.E.C.	16	Metal	
649	Supervisor, Co. official	189	Silver Ore Mining, N.E.C.	16	Metal	18
847	Mucking machine operator	612	Silver Ore Mining, N.E.C.	16	Metal	
053	Utility man	77	Crushed & Broken Limestone Mining, N.E.C.	17	Stone	
376	Truck driver	133	Crushed & Broken Limestone Mining, N.E.C.	17	Stone	
376	Truck driver	125	Crushed & Broken Limestone Mining, N.E.C.	17	Stone	
604	Mechanic	70	Crushed & Broken Limestone Mining, N.E.C.	17	Stone	
782	Front-end loader operator	115	Crushed & Broken Limestone Mining, N.E.C.	17	Stone	5
747	Scaling (hand)	54	Crushed & Broken Limestone Mining, N.E.C.	18	Stone	
807	Blaster, powder gang	82	Crushed & Broken Limestone Mining, N.E.C.	18	Stone	
847	Scaling (mechanical)	111	Crushed & Broken Limestone Mining, N.E.C.	18	Stone	3
807	Blaster, powder gang	186	Crushed & Broken Limestone Mining, N.E.C.	19	Stone	
847	Scaling (mechanical)	143	Crushed & Broken Limestone Mining, N.E.C.	19	Stone	3
782	Drill operator, rotary	225	Crushed & Broken Limestone Mining, N.E.C.	19	Stone	
079	Crusher operator, worker	42	Crushed & Broken Limestone Mining, N.E.C.	20	Stone	
376	Truck driver	44	Crushed & Broken Limestone Mining, N.E.C.	20	Stone	
376	Truck driver	27	Crushed & Broken Limestone Mining, N.E.C.	20	Stone	
782	Front-end loader operator	51	Crushed & Broken Limestone Mining, N.E.C.	20	Stone	
782	Front-end loader operator	51	Crushed & Broken Limestone Mining, N.E.C.	20	Stone	5
376	Truck driver	208	Crushed & Broken Limestone Mining, N.E.C.	21	Stone	
616	Laborer, bullgang	134	Crushed & Broken Limestone Mining, N.E.C.	21	Stone	
634	Drill operator, rotary	188	Crushed & Broken Limestone Mining, N.E.C.	21	Stone	4
376	Roof bolter, rock	240	Crushed & Broken Limestone Mining, N.E.C.	21	Stone	
782	Front-end loader operator	77	Limestone	22	Stone	
782	Front-end loader operator	46	Limestone	22	Stone	
782	Front-end loader operator	44	Limestone	22	Stone	
782	Front-end loader operator	43	Limestone	22	Stone	4
807	Blaster, powder gang	79	Gypsum Mining	23	MNM	
807	Blaster, powder gang	12	Gypsum Mining	23	MNM	
934	Drill operator, jumbo percussion	45	Gypsum Mining	23	MNM	3
079	Crusher operator, worker	151	Gypsum Mining	24	MNM	
782	Front-end loader operator	141	Gypsum Mining	24	MNM	
782	Front-end loader operator	93	Gypsum Mining	24	MNM	
807	Blaster, powder gang	159	Gypsum Mining	24	MNM	5
376	Blaster, powder gang	181	Gypsum Mining	24	MNM	
734	Drill operator, rotary air	240	Crushed & Broken Limestone Mining, N.E.C.	25	Stone	
807	Blaster, powder gang	340	Crushed & Broken Limestone Mining, N.E.C.	25	Stone	
807	Blaster, powder gang	197	Crushed & Broken Limestone Mining, N.E.C.	25	Stone	4
616	Roof bolter, mounted	350	Crushed & Broken Limestone Mining, N.E.C.	25	Stone	
634	Drill operator, rotary	98	Crushed & Broken Limestone Mining, N.E.C.	26	Stone	
782	Front-end loader operator	113	Crushed & Broken Limestone Mining, N.E.C.	26	Stone	2
807	Blaster, powder gang	432	Crushed & Broken Limestone Mining, N.E.C.	27	Stone	
807	Blaster, powder gang	421	Crushed & Broken Limestone Mining, N.E.C.	27	Stone	3
048	Roof bolter, mounted	588	Crushed & Broken Limestone Mining, N.E.C.	27	Stone	
046	Roof bolter, rock	212	Crushed & Broken Limestone Mining, N.E.C.	28	Stone	
399	Stone polisher/cutter	185	Crushed & Broken Limestone Mining, N.E.C.	28	Stone	
616	Laborer, bullgang	197	Crushed & Broken Limestone Mining, N.E.C.	28	Stone	
847	Scaling (mechanical)	144	Crushed & Broken Limestone Mining, N.E.C.	28	Stone	5

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Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
807	Track man; track gang	249	Crushed & Broken Limestone Mining, N.E.C.	28	Stone	
604	Mechanic	376	Crushed & Broken Limestone Mining, N.E.C.	29	Stone	
807	Blaster, powder gang	465	Crushed & Broken Limestone Mining, N.E.C.	29	Stone	3
782	Blaster, powder gang	482	Crushed & Broken Limestone Mining, N.E.C.	29	Stone	
376	Truck driver	87	Crushed & Broken Limestone Mining, N.E.C.	30	Stone	
782	Front-end loader operator	33	Crushed & Broken Limestone Mining, N.E.C.	30	Stone	
807	Blaster, powder gang	70	Crushed & Broken Limestone Mining, N.E.C.	30	Stone	3
782	Front-end loader operator	46	Crushed & Broken Limestone Mining, N.E.C.	31	Stone	
807	Blaster, powder gang	112	Crushed & Broken Limestone Mining, N.E.C.	31	Stone	
807	Blaster, powder gang	88	Crushed & Broken Limestone Mining, N.E.C.	31	Stone	
807	Blaster, powder gang	86	Crushed & Broken Limestone Mining, N.E.C.	31	Stone	
807	Blaster, powder gang	74	Crushed & Broken Limestone Mining, N.E.C.	31	Stone	
807	Blaster, powder gang	33	Crushed & Broken Limestone Mining, N.E.C.	31	Stone	6
782	Front-end loader operator	12	Limestone	32	Stone	
847	Scaling (mechanical)	14	Limestone	32	Stone	2
048	Roof bolter, mounted	420	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
604	Mechanic	313	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
604	Mechanic	282	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
613	Cleanup man	499	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
782	Front-end loader operator	305	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
807	Blaster, powder gang	518	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
807	Blaster, powder gang	260	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
847	Scaling (mechanical)	220	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
934	Drill operator, jumbo percussion	401	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	10
782	Front-end loader operator	527	Crushed & Broken Limestone Mining, N.E.C.	33	Stone	
079	Crusher operator, worker	52	Crushed & Broken Limestone Mining, N.E.C.	34	Stone	
376	Truck driver	37	Crushed & Broken Limestone Mining, N.E.C.	34	Stone	
782	Front-end loader operator	155	Crushed & Broken Limestone Mining, N.E.C.	34	Stone	
934	Drill operator, jumbo percussion	109	Crushed & Broken Limestone Mining, N.E.C.	34	Stone	5
376	Blaster, powder gang	328	Crushed & Broken Limestone Mining, N.E.C.	34	Stone	
376	Truck driver	76	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	
376	Truck driver	75	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	
634	Drill operator, rotary	94	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	
782	Front-end loader operator	151	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	
782	Front-end loader operator	94	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	
782	Front-end loader operator	56	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	
807	Blaster, powder gang	258	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	
847	Scaling (mechanical)	104	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	9
376	Blaster, powder gang	281	Crushed & Broken Limestone Mining, N.E.C.	35	Stone	
376	Truck driver	86	Crushed & Broken Limestone Mining, N.E.C.	36	Stone	
376	Truck driver	78	Crushed & Broken Limestone Mining, N.E.C.	36	Stone	
634	Drill operator, rotary	87	Crushed & Broken Limestone Mining, N.E.C.	36	Stone	
782	Front-end loader operator	46	Crushed & Broken Limestone Mining, N.E.C.	36	Stone	
847	Scaling (mechanical)	86	Crushed & Broken Limestone Mining, N.E.C.	36	Stone	5
053	Utility man	138	Crushed & Broken Limestone Mining, N.E.C.	37	Stone	
604	Mechanic	21	Crushed & Broken Limestone Mining, N.E.C.	37	Stone	
782	Front-end loader operator	335	Crushed & Broken Limestone Mining, N.E.C.	37	Stone	
807	Blaster, powder gang	253	Crushed & Broken Limestone Mining, N.E.C.	37	Stone	
833	Drill helper	380	Crushed & Broken Limestone Mining, N.E.C.	37	Stone	
847	Scaling (mechanical)	138	Crushed & Broken Limestone Mining, N.E.C.	37	Stone	7
058	Truck driver	380	Crushed & Broken Limestone Mining, N.E.C.	37	Stone	
782	Front-end loader operator	621	Crushed & Broken Limestone Mining, N.E.C.	38	Stone	
376	Truck driver	401	Crushed & Broken Limestone Mining, N.E.C.	38	Stone	
634	Drill operator, rotary	437	Crushed & Broken Limestone Mining, N.E.C.	38	Stone	
807	Blaster, powder gang	210	Crushed & Broken Limestone Mining, N.E.C.	38	Stone	
807	Blaster, powder gang	68	Crushed & Broken Limestone Mining, N.E.C.	38	Stone	5
847	Scaling (mechanical)	71	Crushed & Broken Limestone Mining, N.E.C.	39	Stone	
934	Drill operator, jumbo percussion	86	Crushed & Broken Limestone Mining, N.E.C.	39	Stone	3
728	Blaster, powder gang	143	Crushed & Broken Limestone Mining, N.E.C.	39	Stone	
782	Blaster, powder gang	500	Crushed & Broken Limestone Mining, N.E.C.	40	Stone	
376	Truck driver	89	Crushed & Broken Limestone Mining, N.E.C.	40	Stone	
634	Drill operator, rotary	151	Crushed & Broken Limestone Mining, N.E.C.	40	Stone	
782	Front-end loader operator	354	Crushed & Broken Limestone Mining, N.E.C.	40	Stone	
847	Scaling (mechanical)	499	Crushed & Broken Limestone Mining, N.E.C.	40	Stone	5
376	Truck driver	493	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	
376	Truck driver	480	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	
376	Truck driver	151	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	
376	Truck driver	147	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	
634	Drill operator, rotary	410	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	
634	Drill operator, rotary	94	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	
782	Front-end loader operator	438	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	

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Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
847	Scaling (mechanical)	750	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	
847	Scaling (mechanical)	333	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	10
782	Front-end loader operator	982	Crushed & Broken Limestone Mining, N.E.C.	41	Stone	
376	Front-end loader operator	206	Crushed & Broken Limestone Mining, N.E.C.	42	Stone	4
376	Truck driver	157	Crushed & Broken Limestone Mining, N.E.C.	42	Stone	
376	Truck driver	137	Crushed & Broken Limestone Mining, N.E.C.	42	Stone	
634	Drill operator, rotary	20	Crushed & Broken Limestone Mining, N.E.C.	42	Stone	
376	Truck driver	141	Crushed & Broken Limestone Mining, N.E.C.	43	Stone	
807	Blaster, powder gang	88	Crushed & Broken Limestone Mining, N.E.C.	43	Stone	3
601	Truck driver	156	Crushed & Broken Limestone Mining, N.E.C.	43	Stone	
376	Truck driver	585	Crushed & Broken Limestone Mining, N.E.C.	44	Stone	
376	Truck driver	549	Crushed & Broken Limestone Mining, N.E.C.	44	Stone	
734	Drill operator, rotary air	1145	Crushed & Broken Limestone Mining, N.E.C.	44	Stone	
807	Blaster, powder gang	789	Crushed & Broken Limestone Mining, N.E.C.	44	Stone	5
048	Drill operator, rotary air	864	Crushed & Broken Limestone Mining, N.E.C.	44	Stone	
376	Truck driver	108	Crushed & Broken Stone Mining, N.E.C.	45	Stone	
807	Blaster, powder gang	112	Crushed & Broken Stone Mining, N.E.C.	45	Stone	3
782	Front-end loader operator	311	Crushed & Broken Stone Mining, N.E.C.	45	Stone	
782	Front-end loader operator	424	Crushed & Broken Limestone Mining, N.E.C.	46	Stone	
782	Front-end loader operator	336	Crushed & Broken Limestone Mining, N.E.C.	46	Stone	
782	Front-end loader operator	332	Crushed & Broken Limestone Mining, N.E.C.	46	Stone	4
778	Front-end loader operator	496	Crushed & Broken Limestone Mining, N.E.C.	46	Stone	
728	Complete load-haul-dump	182	Salt Mining	47	MNM	
728	Complete load-haul-dump	179	Salt Mining	47	MNM	
807	Blaster, powder gang	112	Salt Mining	47	MNM	
376	Bobcat operator	260	Salt Mining	47	MNM	4
807	Blaster, powder gang	522	Salt Mining	48	MNM	2
782	Complete load-haul-dump	824	Salt Mining	48	MNM	
807	Blaster, powder gang	436	Salt Mining	49	MNM	2
847	Complete load-haul-dump	469	Salt Mining	49	MNM	
734	Drill operator, rotary air	104	Lime, N.E.C.	50	Stone	1
376	Truck driver	95	Dimension Limestone Mining	51	Stone	2
807	Truck driver	217	Dimension Limestone Mining	51	Stone	
807	Scaling (mechanical)	328	Crushed & Broken Limestone Mining, N.E.C.	52	Stone	3
376	Truck driver	75	Crushed & Broken Limestone Mining, N.E.C.	52	Stone	
634	Drill operator, rotary	191	Crushed & Broken Limestone Mining, N.E.C.	52	Stone	
376	Truck driver	85	Crushed & Broken Limestone Mining, N.E.C.	53	Stone	
376	Truck driver	64	Crushed & Broken Limestone Mining, N.E.C.	53	Stone	
376	Truck driver	61	Crushed & Broken Limestone Mining, N.E.C.	53	Stone	
782	Front-end loader operator	7	Crushed & Broken Limestone Mining, N.E.C.	53	Stone	4
782	Front-end loader operator	16	Crushed & Broken Limestone Mining, N.E.C.	54	Stone	1
376	Truck driver	5	Crushed & Broken Sandstone Mining	55	Stone	
376	Truck driver	3	Crushed & Broken Sandstone Mining	55	Stone	
376	Truck driver	0	Crushed & Broken Sandstone Mining	55	Stone	
782	Front-end loader operator	13	Crushed & Broken Sandstone Mining	55	Stone	
847	Scaling (mechanical)	11	Crushed & Broken Sandstone Mining	55	Stone	5
376	Truck driver	143	Crushed & Broken Limestone Mining, N.E.C.	56	Stone	
376	Truck driver	142	Crushed & Broken Limestone Mining, N.E.C.	56	Stone	
634	Drill operator, rotary	224	Crushed & Broken Limestone Mining, N.E.C.	56	Stone	
782	Front-end loader operator	330	Crushed & Broken Limestone Mining, N.E.C.	56	Stone	
934	Scaling (mechanical)	363	Crushed & Broken Limestone Mining, N.E.C.	56	Stone	5
782	Front-end loader operator	11	Crushed & Broken Limestone Mining, N.E.C.	57	Stone	1
376	Truck driver	84	Crushed & Broken Stone Mining, N.E.C.	58	Stone	
634	Drill operator, rotary	176	Crushed & Broken Stone Mining, N.E.C.	58	Stone	
782	Front-end loader operator	129	Crushed & Broken Stone Mining, N.E.C.	58	Stone	
847	Scaling (mechanical)	208	Crushed & Broken Stone Mining, N.E.C.	58	Stone	5
934	Truck driver	222	Crushed & Broken Stone Mining, N.E.C.	58	Stone	
634	Drill operator, rotary	142	Crushed & Broken Limestone Mining, N.E.C.	59	Stone	
782	Front-end loader operator	118	Crushed & Broken Limestone Mining, N.E.C.	59	Stone	
807	Scaling (mechanical)	226	Crushed & Broken Limestone Mining, N.E.C.	59	Stone	3
079	Crusher operator, worker	427	Crushed & Broken Limestone Mining, N.E.C.	60	Stone	
376	Truck driver	425	Crushed & Broken Limestone Mining, N.E.C.	60	Stone	
734	Drill operator, rotary air	724	Crushed & Broken Limestone Mining, N.E.C.	60	Stone	
782	Front-end loader operator	528	Crushed & Broken Limestone Mining, N.E.C.	60	Stone	5
634	Roof bolter, rock	829	Crushed & Broken Limestone Mining, N.E.C.	60	Stone	
634	Front-end loader operator	1090	Crushed & Broken Limestone Mining, N.E.C.	61	Stone	
053	Utility man	638	Crushed & Broken Limestone Mining, N.E.C.	61	Stone	
376	Truck driver	591	Crushed & Broken Limestone Mining, N.E.C.	61	Stone	
376	Truck driver	500	Crushed & Broken Limestone Mining, N.E.C.	61	Stone	
807	Blaster, powder gang	480	Crushed & Broken Limestone Mining, N.E.C.	61	Stone	5
079	Crusher operator, worker	25	Crushed & Broken Limestone Mining, N.E.C.	62	Stone	

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Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
376	Truck driver	254	Crushed & Broken Limestone Mining, N.E.C.	62	Stone	
782	Front-end loader operator	190	Crushed & Broken Limestone Mining, N.E.C.	62	Stone	
847	Scaling (mechanical)	317	Crushed & Broken Limestone Mining, N.E.C.	62	Stone	5
058	Drill operator, rotary	374	Crushed & Broken Limestone Mining, N.E.C.	62	Stone	
782	Front-end loader operator	12	Crushed & Broken Limestone Mining, N.E.C.	63	Stone	
807	Blaster, powder gang	9	Crushed & Broken Limestone Mining, N.E.C.	63	Stone	2
046	Roof bolter, rock	100	Crushed & Broken Limestone Mining, N.E.C.	64	Stone	
376	Truck driver	73	Crushed & Broken Limestone Mining, N.E.C.	64	Stone	
376	Truck driver	64	Crushed & Broken Limestone Mining, N.E.C.	64	Stone	
782	Front-end loader operator	21	Crushed & Broken Limestone Mining, N.E.C.	64	Stone	
847	Scaling (mechanical)	131	Crushed & Broken Limestone Mining, N.E.C.	64	Stone	5
376	Truck driver	594	Crushed & Broken Limestone Mining, N.E.C.	65	Stone	
782	Front-end loader operator	733	Crushed & Broken Limestone Mining, N.E.C.	65	Stone	
782	Front-end loader operator	672	Crushed & Broken Limestone Mining, N.E.C.	.65	Stone	
807	Blaster, powder gang	565	Crushed & Broken Limestone Mining, N.E.C.	65	Stone	5
734	Front-end loader operator	769	Crushed & Broken Limestone Mining, N.E.C.	65	Stone	
634	Drill operator, rotary	12	Crushed & Broken Limestone Mining, N.E.C.	66	Stone	
782	Front-end loader operator	26	Crushed & Broken Limestone Mining, N.E.C.	66	Stone	
782	Front-end loader operator	19	Crushed & Broken Limestone Mining, N.E.C.	66	Stone	3
376	Truck driver	366	Crushed & Broken Limestone Mining, N.E.C.	67	Stone	
747	Scaling (hand)	180	Crushed & Broken Limestone Mining, N.E.C.	67	Stone	
782	Front-end loader operator	333	Crushed & Broken Limestone Mining, N.E.C.	67	Stone	
782	Front-end loader operator	136	Crushed & Broken Limestone Mining, N.E.C.	67	Stone	5
649	Roof bolter, rock	415	Crushed & Broken Limestone Mining, N.E.C.	67	Stone	
376	Truck driver	124	Crushed & Broken Limestone Mining, N.E.C.	68	Stone	
376	Truck driver	120	Crushed & Broken Limestone Mining, N.E.C.	68	Stone	
634	Drill operator, rotary	80	Crushed & Broken Limestone Mining, N.E.C.	68	Stone	
782	Front-end loader operator	28	Crushed & Broken Limestone Mining, N.E.C.	68	Stone	
847	Scaling (mechanical)	118	Crushed & Broken Limestone Mining, N.E.C.	68	Stone	5
079	Crusher operator, worker	8	Crushed & Broken Limestone Mining, N.E.C.	69	Stone	
376	Truck driver	81	Crushed & Broken Limestone Mining, N.E.C.	69	Stone	
782	Front-end loader operator	41	Crushed & Broken Limestone Mining, N.E.C.	69	Stone	
807	Blaster, powder gang	141	Crushed & Broken Limestone Mining, N.E.C.	69	Stone	5
376	Drill operator, rotary air	468	Crushed & Broken Limestone Mining, N.E.C.	69	Stone	
079	Crusher operator, worker	27	Crushed & Broken Limestone Mining, N.E.C.	70	Stone	
634	Drill operator, rotary	228	Crushed & Broken Limestone Mining, N.E.C.	70	Stone	
634	Drill operator, rotary	81	Crushed & Broken Limestone Mining, N.E.C.	70	Stone	
782	Front-end loader operator	171	Crushed & Broken Limestone Mining, N.E.C.	70	Stone	5
807	Truck driver	259	Crushed & Broken Limestone Mining, N.E.C.	70	Stone	
376	Truck driver	61	Crushed & Broken Limestone Mining, N.E.C.	71	Stone	
376	Truck driver	50	Crushed & Broken Limestone Mining, N.E.C.	71	Stone	
782	Front-end loader operator	18	Crushed & Broken Limestone Mining, N.E.C.	71	Stone	
847	Scaling (mechanical)	71	Crushed & Broken Limestone Mining, N.E.C.	71	Stone	5
058	Blaster, powder gang	172	Crushed & Broken Limestone Mining, N.E.C.	71	Stone	
782	Front-end loader operator	7	Crushed & Broken Limestone Mining, N.E.C.	72	Stone	1
216	Blaster, powder gang	144	Salt Mining	73	MNM	5
376	Truck driver	70	Salt Mining	73	MNM	
602	Electrician	72	Salt Mining	73	MNM	
619	Welder, etc.	129	Salt Mining	73	MNM	
782	Front-end loader operator	36	Salt Mining	73	MNM	
807	Blaster, powder gang	513	Salt Mining	74	MNM	
038	Cutting machine operator	140	Salt Mining	74	MNM	
376	Truck driver	291	Salt Mining	74	MNM	
376	Truck driver	89	Salt Mining	74	MNM	
634	Drill operator, rotary	171	Salt Mining	74	MNM	
747	Scaling (hand)	99	Salt Mining	74	MNM	
782	Front-end loader operator	205	Salt Mining	74	MNM	
847	Scaling (mechanical)	361	Salt Mining	74	MNM	
934	Drill operator, jumbo percussion	168	Salt Mining	74	MNM	9
782	Front-end loader operator	96	Salt Mining	75	MNM	
782	Front-end loader operator	79	Salt Mining	75	MNM	
847	Scaling (mechanical)	66	Salt Mining	75	MNM	
847	Scaling (mechanical)	50	Salt Mining	75	MNM	4
376	Truck driver	52	Crushed & Broken Limestone Mining, N.E.C.	76	Stone	
376	Truck driver	52	Crushed & Broken Limestone Mining, N.E.C.	76	Stone	
634	Drill operator, rotary	22	Crushed & Broken Limestone Mining, N.E.C.	76	Stone	
782	Front-end loader operator	62	Crushed & Broken Limestone Mining, N.E.C.	76	Stone	
847	Scaling (mechanical)	0	Crushed & Broken Limestone Mining, N.E.C.	76	Stone	5
782	Front-end loader operator	405	Salt Mining	77	MNM	
038	Cutting machine operator	214	Salt Mining	77	MNM	
488	Dry screen plant operator	317	Salt Mining	77	MNM	

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Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
488	Dry screen plant operator	253	Salt Mining	77	MNM	
488	Dry screen plant operator	223	Salt Mining	77	MNM	
782	Front-end loader operator	310	Salt Mining	77	MNM	
782	Front-end loader operator	168	Salt Mining	77	MNM	
807	Blaster, powder gang	321	Salt Mining	77	MNM	
807	Blaster, powder gang	270	Salt Mining	77	MNM	
934	Drill operator, jumbo percussion	238	Salt Mining	77	MNM	10
376	Truck driver	125	Crushed & Broken Limestone Mining, N.E.C.	78	Stone	
782	Front-end loader operator	70	Crushed & Broken Limestone Mining, N.E.C.	78	Stone	
807	Blaster, powder gang	123	Crushed & Broken Limestone Mining, N.E.C.	78	Stone	
847	Scaling (mechanical)	49	Crushed & Broken Limestone Mining, N.E.C.	78	Stone	5
850	Drill operator, rotary air	147	Crushed & Broken Limestone Mining, N.E.C.	78	Stone	
376	Truck driver	81	Crushed & Broken Limestone Mining, N.E.C.	79	Stone	
376	Truck driver	58	Crushed & Broken Limestone Mining, N.E.C.	79	Stone	
634	Drill operator, rotary	80	Crushed & Broken Limestone Mining, N.E.C.	79	Stone	
782	Front-end loader operator	29	Crushed & Broken Limestone Mining, N.E.C.	79	Stone	
847	Scaling (mechanical)	57	Crushed & Broken Limestone Mining, N.E.C.	79	Stone	5
079	Crusher operator, worker	120	Crushed & Broken Limestone Mining, N.E.C.	80	Stone	
634	Drill operator, rotary	125	Crushed & Broken Limestone Mining, N.E.C.	80	Stone	
747	Scaling (hand)	59	Crushed & Broken Limestone Mining, N.E.C.	80	Stone	
782	Front-end loader operator	94	Crushed & Broken Limestone Mining, N.E.C.	80	Stone	5
028	Truck driver	354	Crushed & Broken Limestone Mining, N.E.C.	80	Stone	
376	Truck driver	787	Crushed & Broken Limestone Mining, N.E.C.	81	Stone	
604	Mechanic	384	Crushed & Broken Limestone Mining, N.E.C.	81	Stone	
634	Drill operator, rotary	1054	Crushed & Broken Limestone Mining, N.E.C.	81	Stone	
649	Supervisor, Co. official	856	Crushed & Broken Limestone Mining, N.E.C.	81	Stone	
782	Front-end loader operator	74	Crushed & Broken Limestone Mining, N.E.C.	81	Stone	5
376	Truck driver	249	Lead-Zinc Ore Mining, N.E.C.	82	Metal	
726	Grizzly man	299	Lead-Zinc Ore Mining, N.E.C.	82	Metal	
782	Front-end loader operator	224	Lead-Zinc Ore Mining, N.E.C.	82	Metal	
634	Blaster, powder gang	544	Lead-Zinc Ore Mining, N.E.C.	82	Metal	4
782	Truck driver	587	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
376	Truck driver	382	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
376	Truck driver	126	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
376	Truck driver	115	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
376	Truck driver	86	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
376	Truck driver	53	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
649	Supervisor, Co. official	158	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
782	Front-end loader operator	620	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
782	Front-end loader operator	236	Lead-Zinc Ore Mining, N.E.C.	83	Metal	
782	Front-end loader operator	136	Lead-Zinc Ore Mining, N.E.C.	83	Metal	10
376	Truck driver	806	Lead-Zinc Ore Mining, N.E.C.	84	Metal	
376	Truck driver	384	Lead-Zinc Ore Mining, N.E.C.	84	Metal	
747	Scaling (hand)	430	Lead-Zinc Ore Mining, N.E.C.	84	Metal	
782	Front-end loader operator	1306	Lead-Zinc Ore Mining, N.E.C.	84	Metal	
782	Front-end loader operator	340	Lead-Zinc Ore Mining, N.E.C.	84	Metal	
782	Front-end loader operator	310	Lead-Zinc Ore Mining, N.E.C.	84	Metal	
807	Blaster, powder gang	284	Lead-Zinc Ore Mining, N.E.C.	84	Metal	
969	Motorman	165	Lead-Zinc Ore Mining, N.E.C.	84	Metal	9
782	Scaling (hand)	2014	Lead-Zinc Ore Mining, N.E.C.	84	Metal	
028	Scoop-tram operator	227	Lead-Zinc Ore Mining, N.E.C.	85	Metal	
376	Truck driver	204	Lead-Zinc Ore Mining, N.E.C.	85	Metal	
604	Mechanic	-7	Lead-Zinc Ore Mining, N.E.C.	85	Metal	
782	Front-end loader operator	242	Lead-Zinc Ore Mining, N.E.C.	85	Metal	
376	Blaster, powder gang	244	Lead-Zinc Ore Mining, N.E.C.	85	Metal	5
048	Front-end loader operator	485	Lead-Zinc Ore Mining, N.E.C.	86	Metal	
046	Roof bolter, rock	139	Lead-Zinc Ore Mining, N.E.C.	86	Metal	
376	Truck driver	286	Lead-Zinc Ore Mining, N.E.C.	86	Metal	
376	Truck driver	275	Lead-Zinc Ore Mining, N.E.C.	86	Metal	
782	Front-end loader operator	189	Lead-Zinc Ore Mining, N.E.C.	86	Metal	5
376	Truck driver	176	Lime, N.E.C.	87	Stone	
747	Scaling (hand)	55	Lime, N.E.C.	87	Stone	
807	Blaster, powder gang	180	Lime, N.E.C.	87	Stone	
833	Drill helper	60	Lime, N.E.C.	87	Stone	5
029	Front-end loader operator	231	Lime, N.E.C.	87	Stone	
782	Truck driver	296	Lead-Zinc Ore Mining, N.E.C.	88	Metal	
046	Roof bolter, rock	163	Lead-Zinc Ore Mining, N.E.C.	88	Metal	
053	Utility man	206	Lead-Zinc Ore Mining, N.E.C.	88	Metal	
053	Utility man	168	Lead-Zinc Ore Mining, N.E.C.	88	Metal	
782	Front-end loader operator	204	Lead-Zinc Ore Mining, N.E.C.	88	Metal	5
807	Drill operator, rotary	611	Crushed & Broken Limestone Mining, N.E.C.	89	Stone	

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Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
376	Truck driver	349	Crushed & Broken Limestone Mining, N.E.C.	89	Stone	
782	Front-end loader operator	308	Crushed & Broken Limestone Mining, N.E.C.	89	Stone	
807	Blaster, powder gang	455	Crushed & Broken Limestone Mining, N.E.C.	89	Stone	
807	Blaster, powder gang	444	Crushed & Broken Limestone Mining, N.E.C.	89	Stone	5
807	Front-end loader operator	717	Crushed & Broken Limestone Mining, N.E.C.	90	Stone	
079	Crusher operator, worker	219	Crushed & Broken Limestone Mining, N.E.C.	90	Stone	
634	Drill operator, rotary	215	Crushed & Broken Limestone Mining, N.E.C.	90	Stone	
747	Scaling (hand)	542	Crushed & Broken Limestone Mining, N.E.C.	90	Stone	
807	Blaster, powder gang	477	Crushed & Broken Limestone Mining, N.E.C.	90	Stone	5
376	Truck driver	219	Crushed & Broken Limestone Mining, N.E.C.	91	Stone	
376	Truck driver	120	Crushed & Broken Limestone Mining, N.E.C.	91	Stone	
604	Mechanic	6	Crushed & Broken Limestone Mining, N.E.C.	91	Stone	
847	Scaling (mechanical)	204	Crushed & Broken Limestone Mining, N.E.C.	91	Stone	5
376	Front-end loader operator	438	Crushed & Broken Limestone Mining, N.E.C.	91	Stone	
376	Truck driver	343	Crushed & Broken Limestone Mining, N.E.C.	92	Stone	
782	Front-end loader operator	156	Crushed & Broken Limestone Mining, N.E.C.	92	Stone	
782	Front-end loader operator	57	Crushed & Broken Limestone Mining, N.E.C.	92	Stone	4
833	Drill operator, rotary	508	Crushed & Broken Limestone Mining, N.E.C.	92	Stone	
782	Drill operator, rotary	221	Crushed & Broken Limestone Mining, N.E.C.	93	Stone	
376	Truck driver	85	Crushed & Broken Limestone Mining, N.E.C.	93	Stone	
376	Truck driver	78	Crushed & Broken Limestone Mining, N.E.C.	93	Stone	
782	Front-end loader operator	120	Crushed & Broken Limestone Mining, N.E.C.	93	Stone	
807	Blaster, powder gang	113	Crushed & Broken Limestone Mining, N.E.C.	93	Stone	5
634	Drill operator, jumbo percussion	148	Hydraulic Cement	94	MNM	5
376	Truck driver	69	Hydraulic Cement	94	MNM	
782	Front-end loader operator	58	Hydraulic Cement	94	MNM	
782	Front-end loader operator	32	Hydraulic Cement	94	MNM	
847	Scaling (mechanical)	140	Hydraulic Cement	94	MNM	
376	Truck driver	518	Crushed & Broken Limestone Mining, N.E.C.	95	Stone	
376	Truck driver	165	Crushed & Broken Limestone Mining, N.E.C.	95	Stone	
782	Front-end loader operator	325	Crushed & Broken Limestone Mining, N.E.C.	95	Stone	
934	Drill operator, jumbo percussion	708	Crushed & Broken Limestone Mining, N.E.C.	95	Stone	5
734	Blaster, powder gang	768	Crushed & Broken Limestone Mining, N.E.C.	95	Stone	
376	Truck driver	664	Crushed & Broken Limestone Mining, N.E.C.	96	Stone	
782	Front-end loader operator	690	Crushed & Broken Limestone Mining, N.E.C.	96	Stone	
807	Blaster, powder gang	960	Crushed & Broken Limestone Mining, N.E.C.	96	Stone	
807	Blaster, powder gang	878	Crushed & Broken Limestone Mining, N.E.C.	96	Stone	5
376	Drill operator, rotary	1064	Crushed & Broken Limestone Mining, N.E.C.	96	Stone	
376	Truck driver	0	Crushed & Broken Limestone Mining, N.E.C.	97	Stone	
782	Front-end loader operator	0	Crushed & Broken Limestone Mining, N.E.C.	97	Stone	
934	Drill operator, jumbo percussion	94	Crushed & Broken Limestone Mining, N.E.C.	97	Stone	3
376	Truck driver	24	Crushed & Broken Limestone Mining, N.E.C.	98	Stone	
376	Truck driver	17	Crushed & Broken Limestone Mining, N.E.C.	98	Stone	
782	Front-end loader operator	24	Crushed & Broken Limestone Mining, N.E.C.	98	Stone	
807	Blaster, powder gang	59	Crushed & Broken Limestone Mining, N.E.C.	98	Stone	
934	Drill operator, jumbo percussion	41	Crushed & Broken Limestone Mining, N.E.C.	98	Stone	5
782	Miner, drift	1459	Platinum Group Ore Mining	99	Metal	
029	Mucking machine operator	856	Platinum Group Ore Mining	99	Metal	
376	Truck driver	786	Platinum Group Ore Mining	99	Metal	
376	Truck driver	635	Platinum Group Ore Mining	99	Metal	
376	Truck driver	583	Platinum Group Ore Mining	99	Metal	
376	Truck driver	570	Platinum Group Ore Mining	99	Metal	
376	Truck driver	522	Platinum Group Ore Mining	99	Metal	
376	Truck driver	462	Platinum Group Ore Mining	99	Metal	
376	Truck driver	426	Platinum Group Ore Mining	99	Metal	
376	Truck driver	423	Platinum Group Ore Mining	99	Metal	
376	Truck driver	260	Platinum Group Ore Mining	99	Metal	
728	Complete load-haul-dump	746	Platinum Group Ore Mining	99	Metal	
782	Front-end loader operator	816	Platinum Group Ore Mining	99	Metal	
969	Motorman	171	Platinum Group Ore Mining	99	Metal	
969	Motorman	71	Platinum Group Ore Mining	99	Metal	15
058	Miner, drift	103	Gemstones Mining, N.E.C.	100	MNM	
782	Front-end loader operator	177	Gemstones Mining, N.E.C.	100	MNM	2
807	Miner, drift	925	Platinum Group Ore Mining	101	Metal	
058	Miner, drift	766	Platinum Group Ore Mining	101	Metal	
456	Engineer	438	Platinum Group Ore Mining	101	Metal	
969	Motorman	291	Platinum Group Ore Mining	101	Metal	
969	Motorman	178	Platinum Group Ore Mining	101	Metal	5
029	Mucking machine operator	15	Gold Ore Mining, N.E.C.	102	Metal	
058	Miner, drift	16	Gold Ore Mining, N.E.C.	102	Metal	2
782	Miner, drift	376	Gold Ore Mining, N.E.C.	103	Metal	

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Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
058	Miner, drift	196	Gold Ore Mining, N.E.C.	103	Metal	2
782	Supervisor, Co. official	527	Gold Ore Mining, N.E.C.	104	Metal	1
649	Supervisor, Co. official	56	Crushed & Broken Limestone Mining, N.E.C.	105	Stone	
782	Front-end loader operator	119	Crushed & Broken Limestone Mining, N.E.C.	105	Stone	
807	Blaster, powder gang	103	Crushed & Broken Limestone Mining, N.E.C.	105	Stone	3
376	Blaster, powder gang	533	Crushed & Broken Limestone Mining, N.E.C.	106	Stone	
048	Roof bolter, mounted	275	Crushed & Broken Limestone Mining, N.E.C.	106	Stone	
634	Drill operator, rotary	425	Crushed & Broken Limestone Mining, N.E.C.	106	Stone	
782	Front-end loader operator	109	Crushed & Broken Limestone Mining, N.E.C.	106	Stone	
847	Scaling (mechanical)	251	Crushed & Broken Limestone Mining, N.E.C.	106	Stone	5
728	Roof bolter, mounted	431	Crushed & Broken Stone Mining, N.E.C.	107	Stone	
634	Drill operator, rotary	183	Crushed & Broken Stone Mining, N.E.C.	107	Stone	
807	Blaster, powder gang	277	Crushed & Broken Stone Mining, N.E.C.	107	Stone	3
734	Drill operator, jumbo percussion	337	Gold Ore Mining, N.E.C.	108	Metal	3
029	Mucking machine operator	39	Gold Ore Mining, N.E.C.	108	Metal	
376	Truck driver	152	Gold Ore Mining, N.E.C.	108	Metal	
534	Drill operator, jackleg, stoper	14	Gold Ore Mining, N.E.C.	109	Metal	1
634	Truck driver	542	Gold Ore Mining, N.E.C.	110	Metal	1
807	Truck driver	1018	Gold Ore Mining, N.E.C.	111	Metal	
782	Front-end loader operator	3	Gold Ore Mining, N.E.C.	111	Metal	2
046	Laborer, bullgang	245	Gold Ore Mining, N.E.C.	112	Metal	
616	Laborer, bullgang	166	Gold Ore Mining, N.E.C.	112	Metal	2
376	Mucking machine operator	214	Gold Ore Mining, N.E.C.	113	Metal	
376	Truck driver	92	Gold Ore Mining, N.E.C.	113	Metal	2
807	Truck driver	164	Gold Ore Mining, N.E.C.	114	Metal	1
649	Supervisor, Co. official	110	Gold Ore Mining, N.E.C.	115	Metal	1
376	Truck driver	333	Gold Ore Mining, N.E.C.	116	Metal	
376	Truck driver	257	Gold Ore Mining, N.E.C.	116	Metal	2
376	Mucking machine operator	872	Gold Ore Mining, N.E.C.	117	Metal	
376	Truck driver	687	Gold Ore Mining, N.E.C.	117	Metal	2
376	Front-end loader operator	442	Gold Ore Mining, N.E.C.	118	Metal	1
847	Belt crew	502	Potash Mining	119	MNM	
053	Utility man	67	Potash Mining	119	MNM	
601	Belt crew	444	Potash Mining	119	MNM	
601	Belt crew	272	Potash Mining	119	MNM	
601	Belt crew	272	Potash Mining	119	MNM	
601	Belt crew	178	Potash Mining	119	MNM	
601	Belt crew	75	Potash Mining	119	MNM	
601	Belt crew	51	Potash Mining	119	MNM	
708	Ventilation crew	151	Potash Mining	119	MNM	
708	Ventilation crew	98	Potash Mining	119	MNM	10
048	Oiler, greaser	285	Potash Mining	120	MNM	
036	Continuous miner operator	75	Potash Mining	120	MNM	
036	Continuous miner operator	58	Potash Mining	120	MNM	
036	Continuous miner operator	20	Potash Mining	120	MNM	
601	Belt crew	26	Potash Mining	120	MNM	
602	Electrician	64	Potash Mining	120	MNM	
604	Mechanic	99	Potash Mining	120	MNM	
609	Nipper	121	Potash Mining	120	MNM	
763	Shaft repairer	7	Potash Mining	120	MNM	
950	Shuttle ca operator (electric)	18	Potash Mining	120	MNM	10
376	Ram car operator	329	Potash Mining	121	MNM	
036	Continuous miner operator	185	Potash Mining	121	MNM	
036	Continuous miner operator	38	Potash Mining	121	MNM	
046	Roof bolter, rock	151	Potash Mining	121	MNM	
604	Mechanic	93	Potash Mining	121	MNM	
604	Mechanic	85	Potash Mining	121	MNM	
604	Mechanic	72	Potash Mining	121	MNM	
604	Mechanic	61	Potash Mining	121	MNM	
850	Ram car operator	149	Potash Mining	121	MNM	
850	Ram car operator	71	Potash Mining	121	MNM	10
045	Hang-up man, chute blaster	61	Molybdenum Ore Mining	122	Metal	
058	Miner, drift	50	Molybdenum Ore Mining	122	Metal	
058	Miner, drift	40	Molybdenum Ore Mining	122	Metal	
604	Mechanic	36	Molybdenum Ore Mining	122	Metal	4
046	Roof bolter, rock	74	Salt Mining	123	MNM	
046	Roof bolter, rock	69	Salt Mining	123	MNM	
046	Roof bolter, rock	63	Salt Mining	123	MNM	
634	Drill operator, rotary	70	Salt Mining	123	MNM	
634	Drill operator, rotary	26	Salt Mining	123	MNM	
728	Complete load-haul-dump	86	Salt Mining	123	MNM	

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Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
728	Complete load-haul-dump	58	Salt Mining	123	MNM	
807	Blaster, powder gang	70	Salt Mining	123	MNM	
807	Blaster, powder gang	63	Salt Mining	123	MNM	
847	Scaling (mechanical)	96	Salt Mining	123	MNM	10
833	Drill helper	243	Talc Mining	124	MNM	
934	Drill operator, jumbo percussion	246	Talc Mining	124	MNM	3
782	Mucking machine operator	329	Talc Mining	124	MNM	
367	Shovel operator	79	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
367	Shovel operator	57	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
604	Mechanic	40	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
734	Drill operator, rotary air	56	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
778	Backhoe operator	17	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
782	Front-end loader operator	129	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
807	Blaster, powder gang	133	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
807	Blaster, powder gang	107	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
847	Scaling (mechanical)	124	Crushed & Broken Stone Mining, N.E.C.	125	Stone	
728	Drill operator, jumbo percussion	305	Crushed & Broken Stone Mining, N.E.C.	125	Stone	10
029	Mucking machine operator	350	Salt Mining	126	MNM	
038	Cutting machine operator	218	Salt Mining	126	MNM	
079	Crusher operator, worker	78	Salt Mining	126	MNM	
154	Belt cleaner	48	Salt Mining	126	MNM	
604	Mechanic	155	Salt Mining	126	MNM	
634	Drill operator, rotary	32	Salt Mining	126	MNM	
728	Complete load-haul-dump	501	Salt Mining	126	MNM	
728	Complete load-haul-dump	454	Salt Mining	126	MNM	
728	Complete load-haul-dump	196	Salt Mining	126	MNM	
807	Blaster, powder gang	310	Salt Mining	126	MNM	
807	Blaster, powder gang	229	Salt Mining	126	MNM	
847	Scaling (mechanical)	277	Salt Mining	126	MNM	
847	Scaling (mechanical)	152	Salt Mining	126	MNM	14
847	Mucking machine operator	578	Salt Mining	126	MNM	
046	Shuttle car operator (diesel)	419	Clay, Ceramic & Refractory Minerals Mining, N.E.C.	127	MNM	
622	Dump operator	44	Clay, Ceramic & Refractory Minerals Mining, N.E.C.	127	MNM	
634	Drill operator, rotary	122	Clay, Ceramic & Refractory Minerals Mining, N.E.C.	127	MNM	
807	Blaster, powder gang	228	Clay, Ceramic & Refractory Minerals Mining, N.E.C.	127	MNM	
969	Motorman	59	Clay, Ceramic & Refractory Minerals Mining, N.E.C.	127	MNM	5
037	Cutting machine helper	257	Salt Mining	128	MNM	
053	Utility man	165	Salt Mining	128	MNM	
604	Mechanic	82	Salt Mining	128	MNM	
618	Oiler, greaser	88	Salt Mining	128	MNM	
728	Complete load-haul-dump	233	Salt Mining	128	MNM	
728	Complete load-haul-dump	188	Salt Mining	128	MNM	
807	Blaster, powder gang	369	Salt Mining	128	MNM	
847	Scaling (mechanical)	119	Salt Mining	128	MNM	
934	Drill operator, jumbo percussion	233	Salt Mining	128	MNM	10
734	Complete load-haul-dump	384	Salt Mining	128	MNM	
376	Blaster, powder gang	212	Salt Mining	129	MNM	
046	Roof bolter, rock	119	Salt Mining	129	MNM	
376	Truck driver	70	Salt Mining	129	MNM	
604	Mechanic	68	Salt Mining	129	MNM	
613	Cleanup man	66	Salt Mining	129	MNM	
674	Warehouse man	67	Salt Mining	129	MNM	
728	Complete load-haul-dump	89	Salt Mining	129	MNM	
847	Scaling (mechanical)	200	Salt Mining	129	MNM	
921	Hoist operator	58	Salt Mining	129	MNM	
934	Drill operator, jumbo percussion	150	Salt Mining	129	MNM	10
747	Drill operator, rotary air	316	Crushed & Broken Limestone Mining, N.E.C.	130	Stone	
782	Front-end loader operator	116	Crushed & Broken Limestone Mining, N.E.C.	130	Stone	
807	Blaster, powder gang	267	Crushed & Broken Limestone Mining, N.E.C.	130	Stone	
847	Scaling (mechanical)	109	Crushed & Broken Limestone Mining, N.E.C.	130	Stone	4
376	Truck driver	81	Crushed & Broken Limestone Mining, N.E.C.	131	Stone	
376	Truck driver	29	Crushed & Broken Limestone Mining, N.E.C.	131	Stone	
782	Front-end loader operator	122	Crushed & Broken Limestone Mining, N.E.C.	131	Stone	
847	Scaling (mechanical)	95	Crushed & Broken Limestone Mining, N.E.C.	131	Stone	4
029	Front-end loader operator	343	Crushed & Broken Limestone Mining, N.E.C.	132	Stone	5
376	Truck driver	99	Crushed & Broken Limestone Mining, N.E.C.	132	Stone	
376	Truck driver	91	Crushed & Broken Limestone Mining, N.E.C.	132	Stone	
616	Laborer, bullgang	2	Crushed & Broken Limestone Mining, N.E.C.	132	Stone	
634	Drill operator, rotary	335	Crushed & Broken Limestone Mining, N.E.C.	132	Stone	
058	Roof bolter, mounted	181	Crushed & Broken Limestone Mining, N.E.C.	133	Stone	
079	Crusher operator, worker	35	Crushed & Broken Limestone Mining, N.E.C.	133	Stone	

874-DPM-Sample Universe Per MNM NPRM Discussion

Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
376	Truck driver	211	Crushed & Broken Limestone Mining, N.E.C.	133	Stone	
782	Front-end loader operator	120	Crushed & Broken Limestone Mining, N.E.C.	133	Stone	
847	Scaling (mechanical)	97	Crushed & Broken Limestone Mining, N.E.C.	133	Stone	5
048	Roof bolter, mounted	98	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
376	Truck driver	106	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
376	Truck driver	88	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
376	Truck driver	82	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
634	Drill operator, rotary	70	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
782	Front-end loader operator	111	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
782	Front-end loader operator	68	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
807	Blaster, powder gang	112	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
807	Blaster, powder gang	99	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	
847	Scaling (mechanical)	61	Crushed & Broken Limestone Mining, N.E.C.	134	Stone	10
782	Front-end loader operator	407	Crushed & Broken Limestone Mining, N.E.C.	135	Stone	
376	Truck driver	242	Crushed & Broken Limestone Mining, N.E.C.	135	Stone	
376	Truck driver	149	Crushed & Broken Limestone Mining, N.E.C.	135	Stone	
782	Front-end loader operator	178	Crushed & Broken Limestone Mining, N.E.C.	135	Stone	
807	Blaster, powder gang	237	Crushed & Broken Limestone Mining, N.E.C.	135	Stone	
847	Scaling (mechanical)	314	Crushed & Broken Limestone Mining, N.E.C.	135	Stone	
847	Scaling (mechanical)	192	Crushed & Broken Limestone Mining, N.E.C.	135	Stone	
934	Drill operator, jumbo percussion	319	Crushed & Broken Limestone Mining, N.E.C.	135	Stone	8
634	Truck driver	1074	Crushed & Broken Limestone Mining, N.E.C.	136	Stone	
634	Drill operator, rotary	610	Crushed & Broken Limestone Mining, N.E.C.	136	Stone	
634	Drill operator, rotary	594	Crushed & Broken Limestone Mining, N.E.C.	136	Stone	
782	Front-end loader operator	1743	Crushed & Broken Limestone Mining, N.E.C.	136	Stone	4
634	Drill operator, rotary	18	Dimension Limestone Mining	137	Stone	
747	Scaling (hand)	24	Dimension Limestone Mining	137	Stone	
747	Scaling (hand)	18	Dimension Limestone Mining	137	Stone	
782	Front-end loader operator	58	Dimension Limestone Mining	137	Stone	
807	Blaster, powder gang	55	Dimension Limestone Mining	137	Stone	
807	Blaster, powder gang	42	Dimension Limestone Mining	137	Stone	
847	Scaling (mechanical)	6	Dimension Limestone Mining	137	Stone	7
782	Truck driver	577	Crushed & Broken Limestone Mining, N.E.C.	138	Stone	
376	Truck driver	443	Crushed & Broken Limestone Mining, N.E.C.	138	Stone	
634	Drill operator, rotary	687	Crushed & Broken Limestone Mining, N.E.C.	138	Stone	
782	Front-end loader operator	526	Crushed & Broken Limestone Mining, N.E.C.	138	Stone	
807	Blaster, powder gang	439	Crushed & Broken Limestone Mining, N.E.C.	138	Stone	5
782	Front-end loader operator	26	Crushed & Broken Limestone Mining, N.E.C.	139	Stone	
807	Blaster, powder gang	41	Crushed & Broken Limestone Mining, N.E.C.	139	Stone	
847	Scaling (mechanical)	40	Crushed & Broken Limestone Mining, N.E.C.	139	Stone	
847	Scaling (mechanical)	36	Crushed & Broken Limestone Mining, N.E.C.	139	Stone	4
376	Truck driver	154	Dimension Limestone Mining	140	Stone	
376	Truck driver	95	Dimension Limestone Mining	140	Stone	
747	Scaling (hand)	57	Dimension Limestone Mining	140	Stone	
782	Front-end loader operator	77	Dimension Limestone Mining	140	Stone	
782	Front-end loader operator	66	Dimension Limestone Mining	140	Stone	
782	Front-end loader operator	54	Dimension Limestone Mining	140	Stone	
782	Front-end loader operator	43	Dimension Limestone Mining	140	Stone	
807	Blaster, powder gang	132	Dimension Limestone Mining	140	Stone	
847	Scaling (mechanical)	114	Dimension Limestone Mining	140	Stone	10
728	Drill helper	217	Dimension Limestone Mining	140	Stone	
058	Scaling (mechanical)	343	Crushed & Broken Limestone Mining, N.E.C.	141	Stone	
782	Front-end loader operator	224	Crushed & Broken Limestone Mining, N.E.C.	141	Stone	
782	Front-end loader operator	148	Crushed & Broken Limestone Mining, N.E.C.	141	Stone	
782	Front-end loader operator	128	Crushed & Broken Limestone Mining, N.E.C.	141	Stone	
934	Drill operator, jumbo percussion	295	Crushed & Broken Limestone Mining, N.E.C.	141	Stone	5
634	Drill operator, rotary	58	Crushed & Broken Limestone Mining, N.E.C.	142	Stone	
807	Blaster, powder gang	203	Crushed & Broken Limestone Mining, N.E.C.	142	Stone	
807	Blaster, powder gang	188	Crushed & Broken Limestone Mining, N.E.C.	142	Stone	
847	Scaling (mechanical)	124	Crushed & Broken Limestone Mining, N.E.C.	142	Stone	4
028	Scoop-tram operator	14	Gold Ore Mining, N.E.C.	143	Metal	
668	Tractor operator	11	Gold Ore Mining, N.E.C.	143	Metal	3
747	Scoop-tram operator	272	Gold Ore Mining, N.E.C.	143	Metal	
058	Drill operator, rotary	158	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	
376	Truck driver	50	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	
376	Truck driver	36	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	
376	Truck driver	23	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	
634	Drill operator, rotary	50	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	
634	Drill operator, rotary	31	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	
782	Front-end loader operator	4	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	
782	Front-end loader operator	1	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	

874-DPM-Sample Universe Per MNM NPRM Discussion

Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
807	Blaster, powder gang	42	Crushed & Broken Limestone Mining, N.E.C.	144	Stone	9
376	Truck driver	62	Crushed & Broken Limestone Mining, N.E.C.	145	Stone	
634	Drill operator, rotary	119	Crushed & Broken Limestone Mining, N.E.C.	145	Stone	
782	Front-end loader operator	70	Crushed & Broken Limestone Mining, N.E.C.	145	Stone	
807	Blaster, powder gang	120	Crushed & Broken Limestone Mining, N.E.C.	145	Stone	
847	Scaling (mechanical)	118	Crushed & Broken Limestone Mining, N.E.C.	145	Stone	5
376	Truck driver	229	Crushed & Broken Limestone Mining, N.E.C.	146	Stone	
376	Truck driver	218	Crushed & Broken Limestone Mining, N.E.C.	146	Stone	
807	Blaster, powder gang	243	Crushed & Broken Limestone Mining, N.E.C.	146	Stone	
807	Blaster, powder gang	231	Crushed & Broken Limestone Mining, N.E.C.	146	Stone	5
782	Front-end loader operator	244	Crushed & Broken Limestone Mining, N.E.C.	146	Stone	
376	Road grader operator	389	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
053	Utility man	38	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
375	Road grader operator	144	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
376	Truck driver	332	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
376	Truck driver	327	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
376	Truck driver	297	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
376	Truck driver	293	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
376	Truck driver	65	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
778	Backhoe operator	93	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
782	Front-end loader operator	356	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
782	Front-end loader operator	196	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
782	Front-end loader operator	160	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
807	Blaster, powder gang	515	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
807	Blaster, powder gang	338	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
847	Scaling (mechanical)	178	Lead-Zinc Ore Mining, N.E.C.	147	Metal	
934	Drill operator, jumbo percussion	134	Lead-Zinc Ore Mining, N.E.C.	147	Metal	16
376	Truck driver	252	Lead-Zinc Ore Mining, N.E.C.	148	Metal	
376	Truck driver	229	Lead-Zinc Ore Mining, N.E.C.	148	Metal	
782	Front-end loader operator	89	Lead-Zinc Ore Mining, N.E.C.	148	Metal	
934	Drill operator, jumbo percussion	194	Lead-Zinc Ore Mining, N.E.C.	148	Metal	5
782	Blaster, powder gang	384	Lead-Zinc Ore Mining, N.E.C.	148	Metal	
029	Roof bolter, rock	223	Lime, N.E.C.	149	Stone	
634	Drill operator, rotary	64	Lime, N.E.C.	149	Stone	
782	Front-end loader operator	62	Lime, N.E.C.	149	Stone	
847	Scaling (mechanical)	170	Lime, N.E.C.	149	Stone	
847	Scaling (mechanical)	144	Lime, N.E.C.	149	Stone	5
807	Front-end loader operator	339	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
053	Utility man	55	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
375	Road grader operator	97	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
376	Truck driver	195	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
376	Truck driver	111	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
649	Supervisor, Co. official	57	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
747	Scaling (hand)	173	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
782	Front-end loader operator	233	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
782	Front-end loader operator	91	Lead-Zinc Ore Mining, N.E.C.	150	Metal	
807	Blaster, powder gang	226	Lead-Zinc Ore Mining, N.E.C.	150	Metal	10
618	Drill operator, rotary air	145	Crushed & Broken Limestone Mining, N.E.C.	151	Stone	
376	Truck driver	9	Crushed & Broken Limestone Mining, N.E.C.	151	Stone	
782	Front-end loader operator	102	Crushed & Broken Limestone Mining, N.E.C.	151	Stone	
847	Scaling (mechanical)	60	Crushed & Broken Limestone Mining, N.E.C.	151	Stone	4
375	Scaling (mechanical)	251	Crushed & Broken Limestone Mining, N.E.C.	152	Stone	
734	Drill operator, rotary air	245	Crushed & Broken Limestone Mining, N.E.C.	152	Stone	
782	Front-end loader operator	199	Crushed & Broken Limestone Mining, N.E.C.	152	Stone	
807	Blaster, powder gang	172	Crushed & Broken Limestone Mining, N.E.C.	152	Stone	
847	Scaling (mechanical)	157	Crushed & Broken Limestone Mining, N.E.C.	152	Stone	5
825	Front-end loader operator	165	Crushed & Broken Stone Mining, N.E.C.	153	Stone	2
389	Forklift operator	14	Crushed & Broken Stone Mining, N.E.C.	153	Stone	
038	Cutting machine operator	67	Salt Mining	154	MNM	
604	Mechanic	61	Salt Mining	154	MNM	
649	Supervisor, Co. official	65	Salt Mining	154	MNM	
728	Complete load-haul-dump	87	Salt Mining	154	MNM	
728	Complete load-haul-dump	42	Salt Mining	154	MNM	
747	Scaling (hand)	74	Salt Mining	154	MNM	
807	Blaster, powder gang	61	Salt Mining	154	MNM	
920	Cager attendant	65	Salt Mining	154	MNM	8
847	Complete load-haul-dump	169	Salt Mining	155	MNM	
376	Truck driver	123	Salt Mining	155	MNM	
604	Mechanic	153	Salt Mining	155	MNM	
734	Drill operator, rotary air	110	Salt Mining	155	MNM	
930	Skip tender	139	Salt Mining	155	MNM	5

874-DPM-Sample Universe Per MNM NPRM Discussion

Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
376	Truck driver	16	Crushed & Broken Limestone Mining, N.E.C.	156	Stone	1
807	Drill operator, jumbo percussion	329	Salt Mining	157	MNM	5
376	Truck driver	94	Salt Mining	157	MNM	
782	Front-end loader operator	122	Salt Mining	157	MNM	
807	Blaster, powder gang	234	Salt Mining	157	MNM	
825	Bobcat operator	274	Salt Mining	157	MNM	
057	Backhoe operator	196	Dimension Marble Mining	158	Stone	5
389	Forklift operator	141	Dimension Marble Mining	158	Stone	
399	Stone polisher/cutter	137	Dimension Marble Mining	158	Stone	
399	Stone polisher/cutter	135	Dimension Marble Mining	158	Stone	
399	Stone polisher/cutter	132	Dimension Marble Mining	158	Stone	
399	Stone polisher/cutter	18	Dimension Marble Mining	159	Stone	
778	Backhoe operator	19	Dimension Marble Mining	159	Stone	2
029	Front-end loader operator	317	Lime, N.E.C.	160	Stone	9
079	Crusher operator, worker	224	Lime, N.E.C.	160	Stone	
376	Truck driver	302	Lime, N.E.C.	160	Stone	
376	Truck driver	267	Lime, N.E.C.	160	Stone	
634	Drill operator, rotary	264	Lime, N.E.C.	160	Stone	
634	Drill operator, rotary	197	Lime, N.E.C.	160	Stone	
682	Scraper operator	182	Lime, N.E.C.	160	Stone	
747	Scaling (hand)	295	Lime, N.E.C.	160	Stone	
747	Scaling (hand)	257	Lime, N.E.C.	160	Stone	
604	Mechanic	9	Lead-Zinc Ore Mining, N.E.C.	161	Metal	1
634	Miner, drift	393	Gold Ore Mining, N.E.C.	162	Metal	
375	Road grader operator	183	Gold Ore Mining, N.E.C.	162	Metal	
376	Truck driver	376	Gold Ore Mining, N.E.C.	162	Metal	
376	Truck driver	282	Gold Ore Mining, N.E.C.	162	Metal	
616	Laborer, bullgang	144	Gold Ore Mining, N.E.C.	162	Metal	5
807	Scaling (hand)	849	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
079	Crusher operator, worker	3	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
376	Truck driver	589	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
376	Truck driver	444	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
376	Truck driver	326	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
376	Truck driver	274	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
634	Drill operator, rotary	582	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
782	Front-end loader operator	271	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
833	Drill helper	59	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	
847	Scaling (mechanical)	180	Crushed & Broken Limestone Mining, N.E.C.	163	Stone	10
046	Truck driver	220	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
079	Crusher operator, worker	1	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
376	Truck driver	195	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
376	Truck driver	102	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
604	Mechanic	82	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
634	Drill operator, rotary	114	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
747	Scaling (hand)	166	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
782	Front-end loader operator	27	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
847	Scaling (mechanical)	105	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	
847	Scaling (mechanical)	54	Crushed & Broken Limestone Mining, N.E.C.	164	Stone	10
847	Drill operator, rotary	1109	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	
376	Truck driver	174	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	
376	Truck driver	11	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	
376	Truck driver	7	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	
634	Drill operator, rotary	25	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	
782	Front-end loader operator	7	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	
807	Blaster, powder gang	389	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	
807	Blaster, powder gang	351	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	
847	Scaling (mechanical)	230	Crushed & Broken Limestone Mining, N.E.C.	165	Stone	9
029	Scaling (mechanical)	455	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	10
048	Roof bolter, mounted	319	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
376	Truck driver	150	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
376	Truck driver	120	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
376	Truck driver	116	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
376	Truck driver	46	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
634	Drill operator, rotary	86	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
782	Front-end loader operator	269	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
807	Blaster, powder gang	357	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
807	Blaster, powder gang	346	Crushed & Broken Limestone Mining, N.E.C.	166	Stone	
934	Front-end loader operator	539	Crushed & Broken Limestone Mining, N.E.C.	167	Stone	
588	Washer operator	353	Crushed & Broken Limestone Mining, N.E.C.	167	Stone	
782	Front-end loader operator	358	Crushed & Broken Limestone Mining, N.E.C.	167	Stone	
782	Front-end loader operator	223	Crushed & Broken Limestone Mining, N.E.C.	167	Stone	4

874-DPM-Sample Universe Per MNM NPRM Discussion

Job Code	Occupation	*Estimated TC (µg/m3)	Commodity	Mine No.	Mine Type	No. of Samples
053	Utility man	91	Trona Mining	168	Trona	
053	Utility man	75	Trona Mining	168	Trona	
053	Utility man	63	Trona Mining	168	Trona	
053	Utility man	55	Trona Mining	168	Trona	
782	Front-end loader operator	96	Trona Mining	168	Trona	5
053	Utility man	29	Trona Mining	169	Trona	
389	Forklift operator	114	Trona Mining	169	Trona	
602	Electrician	65	Trona Mining	169	Trona	
618	Oiler, greaser	32	Trona Mining	169	Trona	
782	Front-end loader operator	178	Trona Mining	169	Trona	5
053	Utility man	194	Trona Mining	170	Trona	
053	Utility man	103	Trona Mining	170	Trona	
053	Utility man	94	Trona Mining	170	Trona	
782	Front-end loader operator	147	Trona Mining	170	Trona	
782	Front-end loader operator	18	Trona Mining	170	Trona	5
782	Mucking machine operator	292	Silver Ore Mining, N.E.C.	171	Metal	
375	Road grader operator	281	Silver Ore Mining, N.E.C.	171	Metal	
376	Truck driver	187	Silver Ore Mining, N.E.C.	171	Metal	
376	Truck driver	156	Silver Ore Mining, N.E.C.	171	Metal	
516	Tamping machine operator	289	Silver Ore Mining, N.E.C.	171	Metal	
734	Drill operator, rotary air	222	Silver Ore Mining, N.E.C.	171	Metal	
807	Blaster, powder gang	216	Silver Ore Mining, N.E.C.	171	Metal	7
*8-hour full-shift equivalent value where estimated total carbon (TC) = 1.3 x elemental carbon (EC) per settlement agreement formula						874

APPENDIX B

H. JOHN HEAD'S REPSONSE
TO
31-MINE STUDY REPORT

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TECHNICAL AND ECONOMIC FEASIBILITY OF NEW DPM REGULATIONS

By: H. John Head, PE
Principal Mining Engineer

May 2002

Executive Summary

- The DPM Rule is not feasible and the MSHA feasibility conclusions are based upon incorrect assumptions and inaccurate and incomplete data.
- MSHA's technical and economic feasibility analysis for the new rule is based entirely on using its Estimator[1] to predict exposure levels in the 31 mines of the DPM Study, and then to assume that this analysis is applicable to the U.S. underground metal/nonmetal mining industry, a total of about 200 mines. Yet, the 31 mines are not representative of the underground industry and MSHA's feasibility conclusion based on this assumption is incorrect.
- The math which forms the basis for the Estimator's calculations cannot be challenged - total exhaust emissions from diesel equipment (in grams/hr) when diluted with mine ventilation air flows (in cubic feet per minute) yield an estimated DPM concentration (in micro-gram per cubic meter), if the emissions are perfectly mixed with the air flow.
- However, the two input parameters - total exhaust emissions, both raw and reduced by particulate control devices, and mine ventilation air flows - are subject to interpretation and assumptions and MSHA's primary assumptions: perfect air mixing and commercial availability of the feasible and effective filtration devices do not exist in reality.
- DPM sample results in isolated sections of the 31 mines in the study are assumed by MSHA to be representative of on-going DPM exposure levels in those mines, despite the fact that results varied widely - indicative of imperfect mixing. Thus, using the Estimator and assuming complete and thorough mixing of the emissions with

[1] Haney, R.A., and Saseen, G.P., "Estimation of Diesel Particulate Concentrations in Underground Mines," Mining Engineering, April 2000

ventilation is a flaw in the feasibility analysis which renders it invalid as a scientific and engineering based method of analysis.

- Ventilation flows are assumed by MSHA to apply throughout the section where the sample was taken, and effective ventilation for dilution of the exhaust particulate is assumed to exist throughout the mine. This MSHA assumption is negated by the vastly differing sampling results from section to section, and even from individual to individual in the same mine.
- MSHA's feasibility analysis also is rendered invalid by the additional assumption that only equipment operating during the time of the sampling are assumed to need controls, without regard to the total fleet of diesel-powered equipment needed for production.
- Most importantly, emission control devices - exhaust filters or particulate traps - are assumed by MSHA's feasibility analysis to be at least 80 percent effective, but even NIOSH has said that there is no research demonstrating the effective use of these filters in underground environments, especially for larger, plus 250 hp, engines. Again, the assumption upon which MSHA's feasibility determination is based is simply invalid, rendering the conclusion invalid. A further problem with the "put a filter on it" solution espoused by MSHA is that NO_2 levels have been increased on engines fitted with filters, creating an unhealthful working environment.
- MSHA's feasibility analysis assumes that none of the 31 mines will need any major changes to its ventilation system. Only six of the 31 mines are allocated any funding by MSHA's analysis for auxiliary fans and ducting, for a total capital cost of $234,400. In contrast, one mine alone estimates at least $4.4 million in ventilation changes to achieve compliance. MSHA relies on this erroneous limited ventilation system change assumption despite an MSHA and NIOSH conclusion that

mine ventilation systems throughout the industry - especially in underground stone mines – need substantial upgrades.

- MSHA's feasibility conclusion relying on no major ventilation additions in the industry is contradicted by the three trona mines in the study which recorded compliance with the DPM limits using ventilation quantities averaging 1.29 million cubic feet per minute (cfm) (needed for methane gas control). These primary airflows in the trona mines can be contrasted against the eleven stone mines in the study which were out of compliance with the DPM limits and averaged main airflows of only 99,000 cfm (with nine of the fourteen readings estimated by MSHA sampling personnel as essentially zero flow - See Table 1).

Chapter

1

Technical Feasibility

MSHA's "Estimator" – Not Appropriate For Feasibility Determinations

MSHA's "Estimator" – Not Appropriate For Feasibility Determinations

MSHA predicated its entire technical and economic feasibility analysis on the use of the Estimator developed by Haney and Saseen. Excerpts from the DPM Report, with comments inserted by this author shown in [brackets], give a background to MSHA's application of the Estimator.

"General Description of the Estimator

"The Estimator is a computerized spreadsheet program that uses Microsoft® Excel software **[to]** help mine operators determine which control or combination of controls would be most appropriate to reduce DPM concentrations to required levels. The Estimator mathematically calculates the effect of any combination of engineering and ventilation controls on existing DPM concentrations in a given production area of a mine. This model is in the form of a spreadsheet template permitting instant display of outcomes as inputs are altered. A detailed description of the design and functioning of the Estimator is provided in "Estimation of Diesel Particulate Concentrations in Underground Mines," (Haney, R.A., and Saseen, G.P., Mining Engineering, April 2000) included in Appendix VII [to MSHA's draft Report].

"Methodology for Applying the Estimator

"The methodology for applying the Estimator was the same for all mines, as follows:

1. "A mine map was reviewed so that each DPM sample result could **[theoretically]** be related to relevant mining operations and ventilation flows. In some cases, the DPM concentrations were plotted on the map. **[As shown below, in application,**

actual ventilation was often ignored in favor of assumed and incorrect ventilation values by MSHA.]

2. "The sample result having the highest DPM concentration was selected as the basis for the analysis because it represents the "worst case." For five of the mines, a second analysis was also performed due either to questions regarding the validity of the "worst case" sample," or because the "worst case" sample was in an isolated location that was unrepresentative of the mine as a whole. **[MSHA's diversion from the "worst case" protocol was not anticipated and introduced bias into the Estimator use by rejecting high results that were the actual "worse case."]**

3. "The source(s) of DPM that contributed to that "worst case" sample result was determined to be the diesel-powered equipment in the immediate vicinity of the sample plus any upstream equipment whose emissions were carried to the sampler by the mine's ventilation; **[In application, many units of diesel equipment that add to the DPM measured were not included in the MSHA Estimator calculations.]**

4. "Three estimator spreadsheets were developed for each mine, including the baseline that reflects conditions prior to **[theoretically]** implementing any DPM controls, one reflecting the controls **[assumed by MSHA to be]** needed to comply with the interim DPM concentration limit of 400_{TC} $\mu g/m^3$, and one reflecting the DPM controls **[assumed by MSHA to be]** needed to comply with the final DPM concentration limit of 160_{TC} $\mu g/m^3$. **[In application, most controls assumed by MSHA to be effective in reducing DPM to the applicable standard are not commercially available and have not been tested in mines. Moreover, the control most effective, massive increases in ventilation to bring the non compliant mines to the same levels as the trona mines, were ignored by MSHA, most likely because installation of such controls would be both technically not feasible at most mines or would render them non economically viable.]** For the baseline spreadsheet, *****data were **[to be]** entered, including the DPM concentration, DPM emissions rates for each piece of equipment **[selected by MSHA as]** affecting that sample expressed in units of grams per brake horsepower hour (g/bhp-hr), operating hours for ***** **[this]** equipment, horsepower **[for this]** **** equipment, and ventilation rate expressed in cubic feet per minute (cfm); **[In application, there were many data entry errors, including very**

significant errors in ventilation data entry that were contradicted by the notes of the inspectors who conducted the sampling.]

5. "For the spreadsheet that reflected the controls [**MSHA assumed were**] needed to comply with the interim DPM concentration limit, the baseline data were entered, along with data appropriate to the DPM controls selected. [**Effectiveness of the DPM control was used in the spread sheet as reported by the manufacturer, regardless of a lack of testing on underground mining equipment**.] This was a trial process [**by MSHA,**] with different controls **** [**and effectiveness inserted into the estimator, based on filter manufacturers representations**], until a suitable mix of controls was [**hypothetically**] identified that met the interim concentration limit. [**We are not aware of a single instance in which the hypothetical controls assumed to be effective were actually observed in the mine by MSHA.]**

6. For the spreadsheet that reflected the controls [**hypothetically**] needed to comply with the final DPM concentration limit, ***baseline data were again entered, along with data [**theoretical data regarding**] **** additional DPM controls necessary to comply with the final concentration limit. This was also a trial and error process, with different [**hypothetical**] controls added to those used to achieve the interim limit until a suitable mix of [**hypothetical**] controls was identified that met the final limit; and

7. A brief narrative description of the results of each evaluation was prepared [**by MSHA**,] including the relevant sampling data, baseline conditions, and controls [**theoretically**] needed to comply with the interim and final concentration limits."

In Haney and Saseen's paper that describes the Estimator, they discuss the actual mathematics involved:

> "Through its studies in underground mines, MSHA has found mine [diesel particulate] (dp) levels of exposure to be related to [the following eight factors]:
>
> 1. Engine dp emission rates,
> 2. Engine horsepower,
> 3. Number of engines,
> 4. Engine operation time,
> 5. Length of work shift,

6. Quantity of ventilating air used,
7. Fuel properties, and
8. Efficiency of applied control technology

> "Diesel particulate concentrations are directly proportional to changes in items 1 through 5; inversely proportional to airflow (item 6), and directly proportional to the percent of dp remaining after applications of controls (items 7 through 8). The amount of dp remaining after application of a control technology can be obtained by subtracting the control efficiency (expressed as a decimal) from 1.0. In order to facilitate the evaluation of control technology, MSHA has combined these relationships and developed a "Work Place Diesel Emission Control Estimator" model."

Mathematically this can be expressed as

PM Emissions = Factor (1) x Engine dp emission rate (g/hp-hr) x hp x no. of engines x operating time (hr) x shift length (hr)

DPM Conc. Levels = Factor (2) x DPM Emissions / Vent Quantity (cfm)

Where Factor (1) and Factor (2) depend on the units used.

In its analysis, the only control strategies adopted by MSHA were particulate filters and, in some limited cases, low emission engines. DPM emissions were assumed to be reduced by 80 percent by the particulate filters used on the diesel powered equipment. Note that calculations of the DPM concentration levels rely upon the dilution of the diesel particulate in the area with the ventilation flow in that area. To obtain an estimate of the DPM concentration level, the exhaust emissions are assumed by the Estimator to be intimately mixed with the air flow, in a uniform manner. This condition is impossible to achieve in an underground mine, with inconsistent, relatively low speed flows.

MSHA's "Estimator" – Results

In MSHA's Draft Report, Section VIII-B Economic Feasibility, there is a summary of the controls that MSHA predicts will be needed for compliance with the interim and final DPM standards - 400 and 160 micro-gram per cubic meter, respectively. MSHA's conclusion states:

> "Control Technology Required
>
> "The MSHA Estimator was used to examine, for each of the 31 mines in the study, the mix of (additional) equipment controls that could be used to comply with the 400_{TC} $\mu g/m^3$ and the 160_{TC} $\mu g/m^3$ concentration levels. Control equipment evaluated by the Estimator for the 31 mines included commercially-available, off-the-shelf ceramic filters, paper filtration systems, new low DPM emitting engines, and standard auxiliary mine ventilation upgrades (auxiliary fans, flexible ventilation ducts, and repositioning of intake fans)."

MSHA Conclusions Summarized:

400_{TC} µg/m3 interim concentration limit

- 7 mines currently meet the 400_{TC} µg/m3 interim concentration limit
- remaining 24 mines can achieve compliance with new control equipment
  - 24 mines will need to install ceramic filters
  - 1 mine will also need two new engines
  - 1 mine will also need a ventilation upgrade (relocation of intake fans)

160_{TC} µg/m3 final concentration limit

- 2 mines currently meet the 160_{TC} µg/m3 final concentration limit
- remaining 29 mines can achieve compliance with the final concentration limit with new control equipment (in addition to that needed to meet the interim concentration limit)
  - 24 mines will need to install additional ceramic filters

- 2 mines will need to install paper filtration systems
- 11 mines will need to install new low DPM emitting engines
- 5 mines will need to install auxiliary ventilation upgrades

Comments

1. Mine maps were not provided.
   - This effectively prevented a necessary and independent analysis of mine layout, equipment disposition, and ventilation schemes.

2. The Estimator assumes perfect mixing of the body of ventilating air throughout the mine.
   - MSHA has assumed the ventilation measurements used in the Estimator can be met throughout the mine and in all working places. This assumption ignores the low velocity or stagnant zones and isolated re-circulation pockets experienced in all underground mines. The design of the Estimator also assumes that DPM levels are consistently distributed throughout a mine environment and does not account for the high variability of DPM levels, documented by the diesel study. Indeed, the variability in the DPM sampling results at the study mines, even when sampling locations are closely spaced, is proof of the imperfect mixing of the mine atmosphere. This is also indicative of the irregular flow characterized by the low flow rates, particularly in stone and salt mines, with large roadway cross sections.
   - MSHA recognizes that "much higher" DPM samples are collected in isolated parts of a mine on page 78 of the draft report. This phenomena occurs at almost all underground mines. However, MSHA used the Estimator at only three mines to evaluate isolated situations that it judged not to be representative of the mine as a whole. The mine by mine Estimator results cannot represent on-going compliance with the DPM concentration levels because of

the inherent variability of DPM levels and the difficulty with achieving constant ventilation rates throughout a mine. The highly variable DPM sampling results demonstrate this point.

- The issue of MSHA accepting or rejecting DPM sample results leads to a degree of arbitrariness that is inappropriate in a study. MSHA chose to use certain samples in its analysis and chose to reject others, without pre-published criteria. Will inspectors reject anomalous values when undertaking compliance sampling? MSHA should have established unambiguous guidelines for accepting or rejecting samples for the study and should have made them applicable to compliance sampling.
- For example in the oil mist and ANFO protocol sections of the draft report MSHA uses averages of two or more DPM sample measurements, to reduce variability. However the Rule is based on the premise that single samples are accurate enough. Which is it?
- Thus, even if mines limit emissions from selective diesel units, there will always be areas in the mine - with and without active operations - where DPM values will be elevated. This will almost guarantee that every underground metal/nonmetal mine in the US will be on a DPM control plan (initiated by a single sample over the limit anywhere in the mine) soon after the regulation comes into effect. The control plans will be in effect for three years, and will compel the mines to conform to ventilation and diesel maintenance practices very similar to those in use in underground coal mines.
- The MSHA Estimator analysis assumes compliance at levels immediately below the interim and final concentration levels. However, mine operators are not likely to attempt to achieve levels that do not give them some confidence that they will be able to remain in compliance most of the time. DPM levels of 80 percent of the interim and final concentration levels are more realistic

targets. Yet MSHA has not commented on this vital issue of lowered concentration levels needed for practical compliance in underground mines throughout the country. By suggesting that mines only achieve levels just below these compliance levels, MSHA is in effect encouraging mines to be out of compliance just often enough to stay on a DPM Control Plan.

3. Ventilation quantities are the most important input factor for the use of the Estimator.
   - Ventilation quantities, both in the MSHA data base (as reported by the on-site sampling teams) and the Estimator analysis are listed in Table 1. However, reported "Section" quantities on average are less than half those used in the Estimator calculations. This is an obvious and fatal flaw in the use of the Estimator to determine feasibility. Not only has the Estimator analysis assumed perfect distribution of the air available to dilute the exhaust emissions, but MSHA's Feasibility analysis has more than doubled - for no apparent reason - the actual quantities observed by its own on-site personnel.
   - Mine C is a perfect example of MSHA's arbitrary allocation of ventilation quantities and the misleading inaccuracy upon which the Estimator is based. There are blank cells for ventilation quantity - both for the main fan or for the section - listed for the first sample (Case 1 SKC-1D-0078) in MSHA's data base, yet 5,000 cfm was allocated in the Estimator calculations. There is a blank cell for the main fan and "0 cfm" flow for the section listed for the second sample (Case 2) (adjacent samples also listed "0 cfm" or "very low" ventilation flow rates), yet 200,000 cfm was used in the calculations. This despite a description of airflow by the sample team; "Michigan 270, 2 R-35's and Cat 966 upstream of this location most of day -- ventilation flow and direction poorly

defined, seemed to travel in several directions a few feet apart (smoke tubes)." The somewhat improbable number of 200,000 cfm may be taken from the mine's ventilation plan which has a total flow of 200,000 cfm listed. However, this flow is split into two circuits close to the intake at the mining level, with no more than 100,000 cfm going to each area of the face line. Taking leakage into account, probably less than 75,000 cfm would have been available to dilute the exhaust emissions of the equipment working near sample SKC-1D-073. It would be physically impossible for the mine to deliver 200,000 cfm to the faceline without significant additional work in the ventilation system - increased capacity fans, high pressure controls directing the air into the face line circuits, and brattices or other controls to ensure that leakage was minimized. The Estimator not only fails to account for the massive changes needed to obtain this phantom ventilation it relies upon, it does not even initiate an analysis of whether the needed ventilation is either technically feasible to produce, given the mine's conditions, or whether it is economically feasible for the mine to install.

- MSHA's Estimator relies on artificially lowered ventilation rates in cfm/hp to determine feasibility that are significantly lower than MSHA has previously recommended - an average of 45 to 50 cfm/hp versus the "rules of thumb" cited by Schnakenberg[2] of 150 cfm/hp, and 150-200 cfm/hp used by Haney[3]. In several cases, MSHA calculates ventilation quantities for technically feasible compliance with the DPM standards - both interim and final - as low as 1 to 4 cfm/hp. These are abnormally low levels for a mine

[2] Schnakenberg Jr., George H., "Estimate of technically feasible DPM levels for underground metal and nonmetal mines." Mining Engineering, September 2001

[3] Haney, Robert A., Personal communication in comments at the Mine Diesel Emission Conference (MDEC), Markham, Ontario, November 2001

to be targeting for its ventilation system, yet apparently acceptable for the MSHA analysis, demonstrating its invalidity.

4. MSHA's Estimator use of main mine ventilation quantities, without regard to the proper distribution of the air flows, is inappropriate.
   - See comments above.
   - No serious consideration was given to the ventilation upgrades needed at many mines to ensure an adequate distribution of air to the working faces to achieve the air mixtures needed to reduce DPM exposures to mandated levels.
   - MSHA reported that the only ventilation upgrade (apart from those at one stone mine which needed changes to reduce recirculation at the mine portals) - needed to achieve compliance with the final concentration level were the addition of auxiliary fans and ventilation ducting at five metal mines (three gold, one molybdenum, and one silver). No ventilation upgrades of any kind were predicted or analyzed by the MSHA estimator for the numerous stone mines where the sometimes poor ventilation distribution is a primary concern.

5. Exhaust filters or particulate traps were the preferred control technology.
   - The universally applied control devices for compliance with the interim and final concentration levels were exhaust filters or particulate traps. Ceramic, actively-regenerated filters were specified at 24 mines, with paper filters specified for two gassy trona mines.
   - Ceramic filters are unproven technology in the underground mining environment. VERT (Verminderung dert Emissionen von Realmaschinen in Tunnelbau), a consortium of several European agencies researching diesel emissions, has tested filters in

tunneling and other construction activities. On page 5742 of the preamble to the Final Rule[4], MSHA describes the extensive European experience with filters on forklift trucks (an average of 8,400 operating hours), stationary engines (an average of 19,200 operating hours), and other diesel-powered equipment (an average of 19,200 operating hours). The VERT table (Table II-4) in the preamble purports to show various filter efficiencies, but no data are given as to engine size, duty cycles, filter type, or regeneration mode, so it is of limited usefulness. Promised additional information[5] on filters has not been not forthcoming.

- DEEP (Diesel Emissions Evaluation Project), a Canadian research organization, is testing filters in underground mining environments, with mixed success.
- DEEP ran a test project in Noranda's New Brunswick Mine[6] that had four different manufacturers' exhaust filters installed, two on LHDs and two on mine haul trucks. (The filter manufacturers engineered and directed the installation of the filters.) Two failed at less than 1000hrs and were replaced by their manufacturer. One of those never met backpressure specifications, was rebuilt to double its original capacity, never met filtration efficiency specifications, and deteriorated from that point. That filter manufacturer has withdrawn from the North American Mining market. The best performing filter accumulated 3500hrs in the test. A very important part of the DEEP project was a <u>very</u> strict maintenance procedure incorporating routine testing and periodically, removal and careful cleaning to restore it to allowable

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4 MSHA, "Diesel Particulate Matter Exposure of Underground Metal and Nonmetal Miners; Final Rule." Federal Register, Volume 66, No 13, Pages 5706 to 5910.

5 "More information about the results of the VERT tests on specific filters and how MSHA intends to use this information.... are discussed in Part IV of this preamble." Page 5744 of the Final Rule.

6 McGinn, Sean, "Brunswick Mine Particulate Trap Project, Isolated Zone Study." Mine Diesel Emission Conference (MDEC), Markham, Ontario, November 2001

backpressure specifications. At 250hr intervals, the engine induction, cooling, lubricating and fuel systems as well as gas, smoke and particulate levels in the exhaust were tested and recorded. Servicing of the equipment included removal and washing of catalytic converters and filters in fuel. One of the concerns is the requirement by some exhaust filter manufacturers that they periodically be removed from the exhaust system and "blown-out" with compressed air - emitting clouds of what the filter has been removing from the diesel's exhaust into the mine ventilation air.

- One unexpected result of the DEEP project at the New Brunswick mine, was the discovery that when effective exhaust particulate filters (90%+) are installed and ambient diesel particulate loading declines, inherent leakage in the exhaust system becomes a significant source of DPM. To correct this situation will require redesign of the exhaust system, including manifolds.
- A RFQ for exhaust filters to test was broadcast in the industry and only four felt that they could meet the specifications. Some of the filters on test are almost one-of-a-kind "prototypes", especially those for non-production equipment.
- DEEP also discovered that light-duty underground "utility" vehicles produce a significant part of the diesel particulate load in mine air, especially when electronic engines and filters reduce the DPM from production equipment. Accordingly, DEEP has a project underway at INCO's Kidd Creek Mine, Sudbury, Ont., Canada to evaluate operating filters on that type of equipment.
- Recently, NIOSH informed the mining industry of the lack of availability of commercially available or mine-proven filters.
- Engine manufacturers have been reluctant in the past to permit, approve of, or certify the use of exhaust particulate traps on their engines because of concerns about elevated engine temperature

due to increase exhaust back pressure. Manufacturers have indicated that warranties would be voided if such retrofit equipment were installed without their approval. MSHA's feasibility Estimator assumes, without any facts, that all filters are acceptable for all equipment, rendering the conclusion of feasibility invalid for this reason alone.

- It is almost impossible for mines to obtain filters from suppliers without undergoing a detailed "research project" to determine duty cycles and the applicability of the filters for the engines and its usage at each specific mine. Requests for proposals for filters are met with a response like, "We can't specify or supply a filter until we've run tests at your mine." Even filters which are in use on a specific engine at one mine will not be specified for the same engine at another mine, because the duty cycles may be different. And yet duty cycles, and the associated exhaust temperatures, vary significantly within the range of use of any particular piece of equipment at a mine. Incorrect specification of a filter may lead to an uncontrolled regeneration similar to those experienced at New Brunswick (see above). The uncontrolled regeneration may actually have prevented serious damage to the engine due to excessively high exhaust temperatures.
- MSHA has ignored this feasibility issue by stating that all filters will be actively regenerated after every shift, and that switching out filters is a 15 minute job for a qualified mechanic. Even if that were so, and many would dispute the time to change out the filter, it does not take into account the time needed to get that vehicle back to the mechanic, or any possible wait time for the mechanic to get to it at the shift change-over. This is not a practical solution to a mine operational issue.
- Recent research by NIOSH and engine testing results at MSHA's Triadelphia Approvals Center has revealed that high NO_2 levels

can be generated when DPM emissions are reduced by using filters. The long-understood trade off between particulate emissions and NO_2 in diesel engines has now been demonstrated to exist in exhaust after-treatment devices. In one mine NO_2 levels jumped to 10 ppm in less than two hours use on a single engine. In another NO_2 in the exhaust stream rose from 36 ppm before the filter to 135 ppm after the filter while particulate (as measured by ECOM-AC Smoke No.) dropped from 7 before the filter to 0 after the filter. Filter manufacturers are apparently considering severe warnings and recommending restrictions on the use of particulate traps and soot filters in underground mines or areas of fixed ventilation quantities, to make sure that sufficient air flow is available to dilute the NO_2 fumes that will be generated. Catalyzed filters, used in the more practical passive regeneration mode, appear to have worse results than those without catalyzed filter media.

6. Insufficient production diesel powered units were selected in MSHA's analysis for fitting with filters.
   - Table 2 lists the recommendations from the MSHA's Estimator analysis for the equipment to be fitted with exhaust particulate filters and compares them with the total "fleet" of diesel powered equipment at each of the mines. MSHA has somewhat arbitrarily selected only the large units (mainly trucks and loaders) to have filters installed on them, when we know that some of the other production equipment (drills, scalers, etc.) will also need them. The columns to compare are highlighted in **Bold**. MSHA recommends the installation of filters and fittings on about 305 units, when there are a total of 720 production units in the "fleets" of the 31 mines.
   - This position is emphasized by a review of Mine S equipment, where 28 units are recommended to be fitted either with filters and

fittings, fittings only, or new engines. This is in contrast to the 149 "production" units of diesel-powered equipment. Engineers at the mine believe that the unmodified units also will require modification to meet the DPM limits because they will add to overall particulate loading in production sections.

Chapter

2

Economic Feasibility

MSHA's Draft Report

Section VIII-B of MSHA's draft report includes a summary of the costs that MSHA has ascribed to the controls described above. MSHA defines economic feasibility as accounting for less than "1% of the affected industry's annual revenues."

An Examination Of MSHA's Cost Conclusions

The costs of compliance estimated by MSHA for the 31 mines can be summarized from the three tables in this section as:

MSHA Total capital costs to achieve:

- interim concentration limit $4.54 million or $147,000 per mine
- final concentration limit $4.36 million or $141,000 per mine
- both concentration limits $8.90 million or $288,000 per mine

MSHA Total annualized capital costs to achieve:

- interim concentration limit $1.38 million or $44,600 per mine
- final concentration limit $0.87 million or $27,900 per mine
- both concentration limits $2.25 million or $72,500 per mine

MSHA Total annual operating costs to achieve:

- interim concentration limit $708,000 or $22,900 per mine
- final concentration limit $579,000 or $18,700 per mine

- both concentration limits $1,287,000 or $41,600 per mine

MSHA Total annual operating and annualized capital costs to achieve:

- interim concentration limit $2.09 million or $67,500 per mine
- final concentration limit $1.44 million or $46,600 per mine
- both concentration limits $3.53 million or $114,100 per mine

If these MSHA costs could be extrapolated to the 196 underground mines operating in the U.S., this would equate to:

Total extrapolated annual operating and annualized capital costs to achieve (compared to the Final Rule FREA):

- interim concentration limit $13.23 million ($17.58 million)
- final concentration limit $9.13 million ($6.61 million)
- both concentration limits $22.36 million ($24.19 million)

However, because the study mines do not represent the US underground mining population, such an extrapolation has only limited usefulness.

Comments

1. These estimated compliance costs for the individual study mines and the resulting extrapolated estimated underground MNM industry compliance costs were all derived from MSHA's inappropriate use of the Estimator, and the resulting estimates s cannot be given any credence.

2. Costs of filters and ovens are low.
    - For example, Mine S has been quoted prices for filters that exceed the MSHA costs by $10,000 for each filter for engines of 100 hp or less and $17,000 for each filter for units with engines larger than

100 hp. Similarly, Mine S will require at least twice the number of ovens than estimated by MSHA.

3. Filter installation costs are low.
   - A flat $1,200. estimated by MSHA for filter and fitting installation is too low for larger filters, where installation costs will exceed $4,000 per filter.

4. Primary ventilation upgrades considered unnecessary by MSHA's analysis will be needed at most mines for compliance.
   - MSHA's feasibility conclusion relying on no major ventilation additions in the industry is contradicted by the three trona mines in the study which recorded the lowest air sampling DPM results with ventilation quantities averaging 1.29 million cubic feet per minute (cfm) (needed for methane gas control). These primary airflows in the trona mines can be contrasted against the eleven stone mines in the study which averaged main airflows of only 99,000 cfm (with nine of the fourteen readings estimated by MSHA sampling personnel as essentially zero flow - See Table 1). It comes as no surprise that the stone industry recorded among the highest DPM results.
   - Primary ventilation system upgrades to increase airflow into and out of the mines are considered by MSHA to be unnecessary at any of the 31 study mines. However they will be needed to dilute DPM emissions with fresh air and to remove potentially contaminated air. These ventilation system upgrades will be difficult and expensive for the MNM industry to implement.
   - For example, Mine S, one of the mines that MSHA said would be able to achieve compliance with the mere installation of exhaust filters and a few new engines, but without any increase in ventilation quantities, has stated that upgrades to its ventilation will

be needed to ensure compliance with the DPM concentration levels. A detailed and thorough analysis of the mine's extended ventilation system was undertaken by one of North America's most respected ventilation engineers - John Marks. The mine presently has a total primary ventilation capacity of about 630,000 cfm. In order to able to provide adequate ventilation to all mining sections, the mine plans to increase its capcity to at least 850,000 cfm. A further increase to 1.1 million cfm will be undertaken to assist the mine to achieve the interim DPM concentration level. Significant additional work will be needed beyond that point to achieve the final DPM concentration level. The mine has spent $2.9 million this year on several 10 ft diameter ventilation boreholes, and projects that the final system will cost about $4.4 million.

- If Mine S's experience is extrapolated to be necessary at only 50 percent of the 198 US MNM mines, and the average cost of primary ventilation system upgrades is assumed to be just 10 percent of that needed for Mine S, then the total costs of primary ventilation upgrades alone is $44 million. However, a realistic estimate of costs cannot be developed using MSHA's data base and analysis due to the incomplete nature of MSHA's data. For that reason, the best estimate remains the feasibility analysis submitted during the Rulemaking..

5. Economic viability should be measured by profitability, or net revenue.
    - The rationale of using 1 percent of gross revenue as the cut-off for economic viability is incorrect.
    - Several of the industries in the table, gold, copper, and lead-zinc, are probably operating at close to zero profitability or below, so

that any substantial additional cost is likely to send them out of business, without regard to gross revenues.

- MSHA's analysis fails to account for significant closures and layoffs in the underground Metal/Non-Metal industries over the past two years. These closures and reductions in Arizona, Missouri, Tennessee, Nevada, and elsewhere demonstrate the need for a profitability based feasibility analysis.

6. Revenue streams reported by MSHA from various mines are artificially very high.
   - For example, MSHA estimated that three salt mines producing a total of less than 4 million tons of ice control salt have a revenue of \$286 million. In stark contrast, this salt is - valued at about \$25 per ton, for a realistic estimated revenue of \$100 million. MSHA also ignores the weather related demand of the salt business and the fact that sales were significantly reduced in 2001-2, reducing industry revenues even further from MSHA projections.

7. There will be additional costs for the maintenance of diesel engines and for maintaining a DPM control plan, i.e. an "approved" ventilation plan beyond the minimum 15 minutes estimated by MSHA .
   - One operator estimates annual additional maintenance involved for retrofit engines and ventilation at 10% of the initial costs of installation.

8. Additional spare equipment will be needed to replace equipment being maintained or checked for exhaust concerns.
   - Down time for equipment waiting to have its filter changed out, or to be worked on by a qualified diesel mechanic after tagging under the new rule is not taken into account. This will likely result in

increased maintenance manpower and more "spare" diesel equipment.

TABLE 1

VENTILATION DATA (1)

Mine	Type	Sample						Air Flow (cfm)					Air Flow (cfm/hp)		
								MSHA Data Base		Estimator			Estimator		
		No.		Location	Type	Void?	Value	Main	Section	Baseline	Interim	Final	Baseline	Interim	Final
A	Copper	SKC-000-5246	934	Jumbo drill	P	No	820	202,300	16,400	50,000	50,000	50,000	28	28	28
AA	Salt	SKC-1D-016	728	LHD	P	No	468	300,000	34,000	3,800	3,800	3,800	4	4	4
B	Silver	SKC-000-5610				Yes	212	42,000	9,500	9,500	9,500	9,500	42	42	42
BB	Lead-Zinc	SKC-1D-082	376	Truck driver	P	No	835	305,000	43,000	20,000	20,000	20,000	17	17	17
C	Stone	SKC-1D-078	934	Jumbo drill	P	Yes	1476	"Blank"	"Blank"	5,000	5,000	5,000	36	36	36
		SKC-1D-073	01	Active mining	A	Yes	930	"Very low"	"0"	200,000	200,000	200,000	98	98	98
CC	Trona	SKC-1D-523	782	FEL	P	No	251	1,500,000	"Detectable"	1,000	1,000	1,000	3	3	3
D	Salt	SKC-000-5262			A	No	968	70,000	15,840	15,000	15,000	15,000	34	34	34
DD	Stone	SKC-1D-546	399	Stone cutter	P	Yes	995	"Undetermined"	"Turbulent"	1,000	1,000	1,000	1	1	1
E	Stone	SKC-000-5009	747	Hand scaling	P	No	229	"Blank"	"Blank" ("Very low")	100,000	100,000	100,000	36	36	36
EE	Salt	SKC-000-5114	847	Mech scaling	P	No	159	60,000 to 100,000	"Very low"	100,000			133		
F	Stone	SKC-1D-063	01	Active mining	A	No	999	"0"	"65,000 ?"	100,000	100,000	100,000	66	66	66
G	Gold	SKC-000-5288	516	Tamping machine	P	No	645	126,381	163,000	150,000	150,000	150,000	190	190	190
H	Stone	SKC-1D-584	634	Rotary drill op.	P	No	1029	400,000	"<100,000"	5,000	5,000	5,000	29	29	29
		SKC-1D-600	376	Truck driver	P	No	923	200,000	52,000	75,000	75,000	75,000	49	49	49
I	Stone	SKC-1D-149	01	Active mining (FEL)	A	No	644	"N/A"	"Slight movement"	20,000	20,000	20,000	8	8	8
J	Stone	SKC-1D-655	728	LHD	P	No	557	390,000	40,000	100,000	100,000	100,000	41	41	41
K	Gold	SKC-000-5521	782	FEL	P	No	2065	533,720	32,617	20,000	20,000	52,000	8	8	20
L	Stone	SKC-1D-575	01	Active mining (Drill cab)	A	No	1395	"0"	"None" ("Very low")	20,000	20,000	20,000	56	56	56
		SKC-1D-574	847	Mech scaling	O	No	811	"0"	"Very low"	30,000	30,000	30,000	14	14	14
M	Gold	SKC-1D-130	01	Active mining	A	No	906	145,000	30,000	30,000	30,000	30,000	19	19	19
N	Stone	SKC-000-5219	934	Jumbo drill	A	No	490	300,000	65,500	51,000	51,000	51,000	21	21	21
O	Stone	SKC-1D-575	01	Active mining (Mech scaler)	P	No	694	" . "	" . "	100,000	100,000	100,000	40	40	40
P	Gold	SKC-000-5372	728	LHD	P	No	995	900,000	"N/A"	86,000	86,000	110,000	40	40	51
Q	Molybdenum	SKC-1D-120	726	Grizzly tender	P	No	279	78,000	7,000 to 10,000	10,000	10,000	10,000	15	15	15
		SKC-1D-109	57	Stope miner	P	Yes	1492	78,000	40,000	10,000	10,000	10,000	56	56	56
R	Lead-Zinc	SKC-000-5186	782	FEL	P	No	148	"Blank"	"Blank" ("Negligible")	100,000			133		
S	Platinum	SKC-000-5455	376	Truck driver	P	No	965	630,000	8,784	26,000	26,000	26,000	9	9	9
T	Gypsum	SKC-1D-647	376	Truck driver	P	No	839	"Blank"	"Blank"	200,000	200,000	200,000	110	110	110
U	Trona	SKC-1D-162	668	Tractor operator	P	No	265	1,016,000	207,360	1,000,000	1,000,000	1,000,000	4,000	4,000	4,000
V	Potash	SKC-1D-633	602	Electrician	P	No	276	144,000	64,000	33,264	33,264	33,000	98	98	97
		SKC-1D-623	604	Mechanic	P	Yes	535	144,000	60,000	10,000	10,000	10,000	26	26	26
W	Stone	SKC-1D-013	934	Jumbo drill	P	No	847	100,000	54,000	1,200	1,200	1,200	1	1	1
X	Gold	SKC-000-5519	516	Jammer	P	No	1566	565,000	9,163	14,000	14,000	28,000	4	4	9
Y	Silver	SKC-000-5199	029	Mucking machine	P	No	1620	160,000	17,500	3,350	3,350	6,900	1	1	2
Z	Troan	SKC-000-5276	668	Tractor operator	P	No	142	1,350,000	34,000	34,000			168		
AVE (2)							791	403,308	34,683	75,948	75,761	77,982	51	44	45

Notes

(1) Ventilation data taken from MSHA spreadsheet data base and from the Estimator tables in the MSHA report

(2) Blank cells and "Text" entries count as "Zero" when computing averages, except as noted below:
- Average section cfm includes 65,000 for Mine F, 5,000 for Mine H, Case 1, and 8,500 for Mine Q, Case 1
- Average cfm/hp excludes trona and potash mines, and mines with no action needed for compliance (i.e. blank cells)

TABLE 2

Mine	To meet interim limit								To meet final limit								Total								Diesel "Fleet" (2)		
	Filters & Fittings			Ftgs Only	Total	New Eng	Aux.		Filters & Fittings			Ftgs Only	Total	New Eng	Aux.		Filters & Fittings			Ftgs Only	Total	New Eng	Aux.		Prodn (3)	Service (4)	Total
	Main	Spare	Total				Fan	Duct	Main	Spare	Total				Fan	Duct	Main	Spare	Total				Fan	Duct			
A	4	4	8	3	11				2	2	4	2	6	2			6	6	12	5	17	2			23	23	46
AA	1	2	3	1	4				2	1	3	2	5				3	3	6	3	9				42	53	95
B									2	1	3		3				2	1	3		3				5	1	6
BB	2	1	3	3	6				1	1	2	3	5	1			3	2	5	6	11	1			32	30	62
C	6	3	9		9				2	1	3		3	5			8	4	12		12	5			14		14
CC									3	1	4	5	9				3	1	4	5	9					185	185
D	2	2	4	2	6									2			2	2	4	2	6	2			8	10	18
DD	2		2		2				3		3		3	1			5		5		5	1			2	5	7
E									2	2	4	2	6				2	2	4	2	6				40	44	84
EE																									8	11	19
F	4	2	6	1	7				2	1	3		3				6	3	9	1	10				13	5	18
G	2	1	3		3				2	1	3		3				4	2	6		6				9	7	16
H	3	3	6	5	11				3	3	6		6	2			6	6	12	5	17	2			26	43	69
I	4	4	8	9	17				2		2		2				6	4	10	9	19				24	19	43
J	3		3		3				2	2	4	2	6				5	2	7	2	9				14	20	34
K	8	2	10		10	2									3	600	8	2	10		10	2	3	600	17	23	40
L	4	3	7	1	8				2	2	4		4	1			6	5	11	1	12	1			17	5	22
M	6	6	12	3	15				1	1	2	1	3	4			7	7	14	4	18	4			24	27	51
N	2	1	3		3				3	3	6		6				5	4	9		9				19	6	25
O	5	2	7		7				3	1	4		4				8	3	11		11				10	2	12
P	10	8	18	9	27				2	2	4	1	5		4	800	12	10	22	10	32		4	800	13	22	35
Q	1		1		1				3	3	6		6		4	800	4	3	7		7		4	800	33	28	61
R																									14	16	30
S	15	7	22	1	23									5			15	7	22	1	23	5			149	146	295
T	6	4	10	1	11				2	2	4	1	5	2			8	6	14	2	16	2			20	22	42
U									2		2	7	9				2		2	7	9					100	100
V	8	8	16	8	24				10	10	20	5	25				18	18	36	13	49					70	70
W	4		4		4				1		1		1	2			5		5		5	2			11	2	13
X	10	10	20	4	24				1	1	2		2		3	600	11	11	22	4	26		3	600	91	80	171
Y	10	10	20	6	26										3	600	10	10	20	6	26		3	600	42	46	88
Z									1		1		1				1		1		1					120	120
TOTAL	122	83	205	57	262	2			59	41	100	31	131	27	17	3400	181	124	305	88	393	29	17	3400	720	1171	1891
COUNT	24	20	24	15	24	1			25	20	25	11	25	11	5	5	29	25	29	19	29	12	5	5	27	30	31

Notes
(1) Recommendations taken from Table A-1 through Table A-31 in the feasibility appendix to the MSHA report
(2) Diesel "Fleet" based on the the mine's own diesel equipment inventory
(3) Production units: Haul trucks, loaders, LHDs, jammers, drills, roof bolters, scalers, and powder rigs
(4) Service units: High reach work platforms, dozers, graders, pick ups, tractors, lube trucks, fork lifts, etc.

APPENDIX C

DIESEL-POWERED EQUIPMENT INVENTORY

Diesel-Powered Units Needed for Production

"Mine"	Commodity	>150hp	<150hp	Total	"Mine"	Commodity	>150hp	<150hp	Total	"Mine"	Commodity	>150hp	<150hp	Total
1	lime	-	1	1	67	marble	4	1	5	133	copper	8	-	8
2	perlite	-	1	1	68	talc	-	1	1	134	copper	5	-	5
3	gold	-	1	1	69	limestone	3	-	3	135	lead/Zinc	8	-	8
4	copper	1	-	1	70	limestone	4	-	4	136	gypsum	4	-	4
5	limestone	-	3	3	71	limestone	3	-	3	137	limestone	9	-	9
6	limestone	4	-	4	72	gold	-	1	1	138	moly	6	7	13
7	limestone	1	2	3	73	gold	-	3	3	139	limestone	6	2	8
8	limestone	1	2	3	74	gold	-	1	1	140	gypsum	5	7	12
9	limestone	3	1	4	75	marble	-	-	-	141	gold	12	10	22
10	lime	3	1	4	76	limestone	4	-	4	142	gypsum	4	-	4
11	limestone	4	-	4	77	gold	-	-	-	143	salt (rock)	4	-	4
12	limestone	2	-	2	78	limestone	11	1	12	144	gold	9	-	9
13	limestone	5	-	5	79	limestone	9	1	10	145	uranium	-	15	15
14	limestone	5	-	5	80	limestone	8	-	8	146	limestone	18	-	18
15	limestone	3	-	3	81	limestone	7	1	8	147	trona	-	63	63
16	limestone	6	-	6	82	limestone	5	-	5	148	lead/Zinc	8	-	8
17	limestone	6	-	6	83	limestone	7	-	7	149	copper	5	7	12
18	limestone	4	-	4	84	limestone	4	-	4	150	gold	6	2	8
19	limestone	5	-	5	85	limestone	8	2	10	151	limestone	16	-	16
20	limestone	4	-	4	86	limestone	5	-	5	152	limestone	6	-	6
21	limestone	8	-	8	87	sandstone	7	-	7	153	uranium	-	16	16
22	limestone	2	1	3	88	limestone	8	-	8	154	limestone	5	5	10
23	limestone	3	2	5	89	salt	4	-	4	155	marble	5	-	5
24	limestone	5	-	5	90	limestone	16	3	19	156	gypsum	8	-	8
25	limestone	5	-	5	91	limestone	7	-	7	157	lead/Zinc	8	-	8
26	gold	-	2	2	92	limestone	5	-	5	158	lead/Zinc	7	-	7
27	shale (humic)	-	1	1	93	limestone	8	4	12	159	gold	9	-	9
28	gold	2	2	4	94	copper	7	-	7	160	lead/Zinc	10	6	16
29	gold/silver	-	1	1	95	gold	-	20	20	161	gold	15	-	15
30	limestone	11	-	11	96	zinc	40	-	40	162	lime	6	-	6
31	shale (humic)	1	-	1	97	borate	-	15	15	163	limestone	8	-	8
32	shale (humic)	1	-	1	98	zinc	21	-	21	164	trona	3	15	18
33	limestone	4	-	4	99	limestone	10	-	10	165	lead/zinc	6	3	9
34	calcite	3	-	3	100	limestone	17	3	20	166	limestone	7	-	7
35	limestone	9	-	9	101	gold	5	1	6	167	potash	-	5	5
36	gemstone	-	4	4	102	salt (rock)	3	-	3	168	limestone	7	-	7
37	limestone	4	2	6	103	gold/silver	12	14	26	169	salt (rock)	2	-	2
38	limestone	5	-	5	104	salt (rock)	20	-	20	170	zinc	17	4	21
39	gold	-	1	1	105	limestone	13	14	27	171	salt	9	-	9
40	limestone	12	1	13	106	silver	8	18	26	172	gold	9	-	9
41	limestone	4	-	4	107	gold/silver	6	4	10	173	zinc	10	5	15
42	limestone	3	-	3	108	zinc ore	9	5	14	174	salt	3	4	7
43	zinc ore	8	-	8	109	salt	15	-	15	175	limestone	7	-	7
44	limestone	6	-	6	110	gold	-	5	5	176	gold	2	7	9
45	limestone	12	2	14	111	limestone	14	-	14	177	trona	3	-	3
46	limestone	6	-	6	112	gold	13	-	13	178	iron ore	7	-	7
47	clay	3	-	3	113	limestone	11	-	11	179	limestone	6	-	6
48	zinc ore	5	1	6	114	gold	3	5	8	180	salt	4	2	6
49	limestone	6	-	6	115	Zin/led/gld/slv	18	-	18	181	potash	-	6	6
50	limestone	2	-	2	116	marble	9	-	9	182	limestone	2	4	6
51	limestone	3	4	7	117	silver	-	24	24	183	limestone	8	-	8
52	limestone	6	-	6	118	zinc	11	-	11	184	lead/zinc	-	2	2
53	marble	5	-	5	119	zinc	10	-	10	185	limestone	8	-	8
54	limestone	5	-	5	120	gold	6	-	6	186	limestone	4	-	4
55	copper/zinc	-	3	3	121	salt	2	-	2	187	trona	-	7	7
56	limestone	3	-	3	122	limestone/gyps	9	-	9	188	trona	-	4	4
57	limestone	3	-	3	123	lead/Zinc	36	-	36	189	copper	-	1	1
58	marble	4	-	4	124	salt	6	1	7	190	lime	16	1	17
59	granite/garnat	3	2	5	125	gold	5	-	5	191	platinum	22	39	61
60	marble	4	-	4	126	gold	5	-	5	192	copper	14	49	63
61	limestone	5	-	5	127	limestone	12	-	12	193	gold	26	12	38
62	limestone	3	1	4	128	limestone	8	-	8	194	molybdenum	16	-	16
63	limestone	5	-	5	129	gypsum	10	-	10	195	potash	-	12	12
64	gold	2	-	2	130	limestone	12	-	12	196	trona	3	11	14
65	sand(industrial)	3	-	3	131	gypsum	8	-	8	Total		1,230	523	1,753
66	limestone	4	-	4	132	salt	13	-	13					

31-MINE STUDY ANALYSIS - FILTERS/FITTINGS/ENGINES

400	filters/ftgs			ftgs	engines	160	filters/ftgs			ftgs	engines	Combined	filters/ftgs			ftgs	total	%	engines
Prod						**Prod**						**Prod**							
<150	5	2	7	0	2	<150	9	6	15	1	3	<150	14	8	22	1	23	7.3%	5
>150	106	72	178	49	0	>150	30	21	51	12	21	>150	136	93	229	61	290	92.7%	
subtotal	111	74	185	49	2	subtotal	39	27	66	13	24	subtotal	150	101	251	62	313		
150-250	41	28	69	18	0	150-250	17	12	29	3	15	150-250	58	40	98	21	119	41.0%	15
250-350	26	24	50	12	0	250-350	5	2	7	5	4	250-350	31	26	57	17	74	25.5%	4
>350	39	20	59	19	0	>350	8	7	15	4	2	>350	47	27	74	23	97	33.4%	2
Support						**Support**						**Support**							
<150	8	8	16	8	0	<150	17	11	28	17	0	<150	25	19	44	25	69		0
>150	3	1	4	0	0	>150	3	3	6	1	3	>150	6	4	10	1	11		
subtotal	11	9	20	8	0	subtotal	20	14	34	18	3	subtotal	31	23	54	26	80		
150-250	2	0	2	0	0	150-250	3	3	6	1	0	150-250	5	3	8	1	9		0
250-350	1	1	2	0	0	250-350	0	0	0	0	1	250-350	1	1	2	0	2		1
>350	0	0	0	0	0	>350	0	0	0	0	2	>350	0	0	0	0	0		2
total	122	83	205	57	2		59	41	100	31	27		181	124	305	88	393	0	0